FIELD WORK AND LABORATORY TECHNIQUES IN GEOGRAPHY

A Textbook for Classes XI—XII

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FIELD WORK AND LABORATORY TECHNIQUES IN GEOGRAPHY

A Textbook For Classes XI—XII

L. S. BHAT
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राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
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Foreword

This book follows the approach taken by the Council in developing a curriculum for Classes XI and XII.

An Editorial Board for geography for the secondary and higher secondary stage was constituted under the Chairmanship of Prof. Moonis Raza. The Editorial Board devoted considerable time to developing the syllabi in geography for Classes IX, X, XI and XII and then to the preparation of manuscripts of different books on the same.

The present book *Field Work and Laboratory Techniques in Geography* is meant for Classes XI and XII. Although it is a separate book, it has been visualised that field work and related activities would be taken up with the relevant portions in theory spread over all the four semesters.

Our thanks are due to Prof. Moonis Raza and his colleagues on the Editorial Board for preparing the syllabi and manuscripts of the books. We are grateful to Prof. L. S. Bhat and Shri Aslam Mahmood for the preparation of the manuscript of this book which was discussed and approved by the Editorial Board. The maps and diagrams included in this book have been prepared by Shri Krishan Kumar of the University of Delhi. Our thanks are also due to Shri S. S. Rastogi and Shri S. C. Sharma of the Department of Education, Delhi Administration, for rendering this book into Hindi in a short period of time.

The preparation of curriculum and textbooks calls for considerable expertise and effort in planning the work, screening, reviewing and editing the book, and finally seeing it through the press. For all this I am grateful to my colleagues in the Department of Education in Social Sciences and Humanities, and particularly to Prof. B. S. Parakh and to Smt. Savita Sinha who was assisted by Smt. Savita Verma. In fact, but for the dedicated and sustained work of Smt. Savita Sinha, the book in its present form would not have seen the light of the day.

Curriculum construction and development of instructional materials are on-going processes and hence every suggestion from the teachers in the light of their experience would be most welcome. These would be taken into account while bringing out the revised version of this book.

SHIB K. MITRA
Director
National Council of Educational
Research and Training

New Delhi
22 July 1977

Preface

The 'plus two' stage in the new educational pattern is an important link in the chain of curricular work, wherein it is intended that the student should branch out on the basis of the foundations laid in the first ten years of schooling devoted to general education. Accordingly, it would be necessary at this crucial stage to broaden and deepen the students' base in geography so that those offering this subject as an elective may develop a keen and intelligent interest in the subject that is so useful in their everyday life as well as in their areas of specialisation. Further, geography being a subject of an interdisciplinary nature, it helps in the study of allied disciplines, especially those like botany and zoology among the natural sciences, and economics, political science, sociology and the like among the social sciences.

Against this background, the Editorial Board, in collaboration with a large number of teachers and various academic agencies interested in improving the teaching of geography at different levels in an atriculated manner, developed a framework of curriculum consisting of systematic geography for two semesters and geography of India for the remaining two semesters.

The volume on physical geography meant to be used in the first semester in Class XI is preceded by two chapters dealing with the nature and scope of geography as a discipline and its place in the world of knowledge. In fact, these two chapters provide an introduction to the entire course spread over four semesters.

Its companion volume deals with human geography. The synthesis of the principles discussed in these two volumes and their application would be discernible in the other two volumes, viz., (1) *India: A General Geography*; and (2) *India: A Regional Geography*. The emphasis on the study of India and on regional geography needs no elaboration.

The Editorial Board is also of the view that the study of geography and real appreciation of its nature and methodology remain incomplete if theoretical study is not complemented by practical work in laboratory and field. Hence it has provided for adequate field and practical work in its course outline and has produced the present volume in this series, entitled *Field Work and Laboratory Techniques in Geography*. The authors of the present book have freely drawn on the Council's earlier book *Practical Geography*, edited by Prof. George Kurien and Prof. B.S. Parekh. The present Editorial Board is, therefore, thankful to the then Geography Panel and the editors of the book.

A workbook in geography for Classes XI and XII is yet another addition in the series introduced by the Editorial Board. This move has been widely appreciated by geography teachers.

I am grateful to Prof. L. S. Bhat and Shri Aslam Mahmood who have written this book. My sincere thanks are also due to Prof. C. D. Deshpande and Prof. Learmonth who went through this manuscript carefully and gave useful suggestions towards its improvement. The maps and diagrams included in this book have been prepared by Shri Krishan Kumar of the University of Delhi. We are indebted to him for this work. Finally, mention may be made of Shri S. S. Rastogi and Shri S. C. Sharma of the Department of Education, Delhi Administration, for rendering this book into Hindi in a very short span of time.

My special thanks are due to Smt. Savita Sinha of the National Council of Educational Research and Training who was responsible for seeing this book through the press. But for her devoted and diligent work, the book would not have seen the light of the day in its present form.

Curriculum construction and development of instructional materials are on-going processes and hence every suggestion from the teachers in the light of their experience would be most welcome. These would be taken into account while bringing out the revised version of this book.

MOONIS RAZA
Chairman
Editorial Board for Geography

New Delhi
22 July 1977

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Chapter 1

INTRODUCTION

GEOGRAPHY, LIKE any other subject either in social or natural sciences, has its own tools and techniques of analysis. Knowledge of the earth upon which people live and work is of great importance, and is becoming increasingly complex with advances in science and technology. Every part of the earth inhabited by mankind presents its own character which is shaped by the interaction between man and his environment. The task of the geographer is, therefore, to (i) study the various features on the surface of the earth, (ii) analyse any inter-relationships between the various features, and (iii) differentiate various parts of the geographical landscape according to their similarities with and contrasts to others.

For the study of the earth as the home of man the geographer's tools are mainly the globe, maps, diagrams, photographs and relief models as well as relevant statistics, books and articles. Nowadays, photographs of the earth are taken by artificial earth satellites which help us in understanding the surface features of the earth, such as landforms, vegetation and minerals.

The globe is a manmade model of the earth. It is the closest approximation to the earth and as such helps us to comprehend the nature of the earth. Maps have been in use for a variety of purposes ever since man started exploring different parts of the earth. Maps of different scales serve as models in the study of different parts of the earth's surface. They are becoming increasingly important in understanding the resources, patterns of their utilisation and in preparing development plans Therefore, maps are one of the major tools of geographical analysis.

There are different kinds of maps. For example, the Survey of India prepares topographical maps which are used in understanding landforms, natural vegetation, cultivated areas, human settlements (rural and urban), patterns of communication, etc. In addition, geographers are required to study the patterns of changes that are taking place on the earth's surface. For this purpose they have to make use of data from fieldwork or statistics already available on all aspects of natural environment, physical and human resources, and their interrelationships, if any. Statistical maps and diagrams are useful tools for this purpose. Cartographic and statistical techniques of analysis have to be employed in geographical studies. Such studies have undergone major changes in the last decade with the availability of electronic computers which reduce the time of compilation and processing of data. Computers are also being used for the preparation of maps or computer graphics which help geographers in understanding complex relationships between different features of the earth's surface. India being a large country, with extreme diversities in its geographical characteristics, it would be helpful to utilise maps, diagrams and photographs to enrich our knowledge about the country.

This book has been written in the hope of bringing out in a practical way several fundamentals of modern geography like its interdisciplinary character; its concern with surface features of the earth, both natural and man-made its emphasis on changing patterns and the development of several complementary geographical insights or aspects.

First of all you are introduced to the art of map-making and the essential features of a map. Scale is an important consideration in the preparation of a map. The proper understanding of the scale helps you to appreciate its relationships with the details shown on a map. Likewise, a knowledge of scale helps you to measure the distance between places, the areas demarcated as forest, water, or cultivated land, and other types of measurement which are essential in scientific geography. In turn, a knowledge of surveying is a necessary basis for an understanding of the art of map-making. In the course of your studies, you may be asked to use a variety of maps ranging from very large-scale maps of a town or a village to Survey of India topographic maps on several scales. A knowledge of survey methods adds to your understanding of the individual qualities of such maps, even though you may not yourself carry out large-scale surveys to prepare original maps. However, original mapping within the modest limits of an exercise *does* become necessary during some types of fieldwork because large-scale maps may not be available for you to plot the features as you see them. Again, some knowledge of map projections is essential for the critical appreciation of distribution maps you see in your atlas, textbook or newspaper. The patterns of distribution are likely to be distorted if the map-maker has not used a projection appropriate to the particular cartographic task.

The book then turns to the techniques of studying the distributional patterns of various features with the help of appropriate diagrams and cartographic techniques. For this purpose, you would require statistical data and base maps. Interpretation of maps requires specialised skills and you must have, for instance, a good knowledge of a variety of conventional signs and symbols used in cartography. For this purpose, the book provides you with material on interpretation of topographical maps and weather charts.

Fieldwork has an important place in geographical studies. It involves careful design of the project; clear statement of the objectives of the study; and preparation of base maps, data collection and compilation schedules and questionnaires for local enquiries. Designs of five projects for field study are presented as illustrations. You are expected to conduct at least one of them, depending on whether your school is in a rural area, or an industrial centre, or a market town.

As stated at the outset, geographical studies can be greatly strengthened by the use of statistical data and techniques of analysis. To this end the book introduces you to some simple statistical techniques and their application to geographical problems.

Chapter 2

MAP-MAKING

SCALES: THEIR USE AND CONSTRUCTION

THE IMPORTANCE of maps in geographical studies has been discussed earlier. We shall now go into the various factors that have to be considered in the preparation of maps. For this purpose, we shall consider first of all certain features that are common to all the maps. Among them scale is an important consideration. It is normally impossible to represent the earth's surface except by a drawing or model at some smaller size. However in approaching any map, we have to consider if it is on a large-scale, say in order to plan a new house or a small piece of land; or in a medium-scale, as in a map of a city or a *tahsil* or *taluka*; or in a small-scale, as in most atlas maps or in the terrestrial globe in the classroom.

The distance between any two points on a map represents an actual distance between the corresponding points on the ground· the ratio between the map distance and the ground distance is the scale of the map. For example, when we speak of the scale being one centimetre to one kilometre we mean that a length of one centimetre on the map corresponds to a distance of one kilometre on the ground. The scale of a map is always expressed in linear scale, i.e. in distance. Large-scale maps are those which depict in detail the geographical features of the area enclosed by them. Such maps cover smaller areas in contrast to small-scale maps. The latter are prepared for showing only the important features of a large area. There will, thus, be some loss of information in the case of small-scale maps, as their information content has to be selective. The choice of proper scale of a map would depend upon the purpose for which it is prepared

Representation of Scale on a Map

There are three ways in which the scale of a map is expressed. (i) by a statement, (ii) by a numerical fraction, and (iii) by a graphical section.

(i) *By a Statement*—In this method, the scale is expressed in words, such as one centimetre to one kilometre, or one inch to one mile, etc. This indicates that one centimetre on the map corresponds to one kilometre on the ground or one inch on the map corresponds to one mile on the ground. This method has two limitations. First, it can be understood only by those who are familiar with the unit of measurement used. Secondly, when a map is reduced or enlarged from the original, the scale will not be the same. This creates problems in measurement.

(ii) *By a Numerical Fraction*—This method of expressing the scale is also referred to as Representative Fraction and is abbreviated as R.F. It gives the ratio between the distance on a map and the corresponding distance on the ground. Thus:

$$\text{R.F.} = \frac{\text{Distance on the map}}{\text{Distance on the ground}}$$

The numerator is always taken as one. It may be written either as $\frac{1}{50{,}000}$ or 1 50,000. This means that one unit on the map represents 50,000 of the same units on the ground. It should be noted that the unit of distance for the numerator and denominator must be the same. Hence, this method of stating the scale is independent of any particular unit of measurement. It can be converted into any unit and, therefore, in reading and making maps it has a universal application, i.e., it can be used by any country according to that country's accepted unit of measurement. (However, if a map is photographically enlarged or, more often reduced, the R.F. will no longer be true, and the graphical scale is better.)

Examples

1. Calculate the R.F. when the scale is five centimetres to one kilometre.

The scale of the map is five centimetres to one kilometre, i.e. five centimetres on the map represent one kilometre, i.e. 100,000 centimetres on the ground.

Now, in R.F. the numerator, i.e. the map distance is always one.

$$\therefore \text{R.F.} = \frac{\text{Distance on the map}}{\text{Distance on the ground}}$$

$$= \frac{5}{100{,}000}$$

$$= \frac{1}{20{,}000}$$

$$\text{or} \quad 1 : 20{,}000$$

2. The scale of a map is one inch to two miles. Find the R.F.

The scale of the map is one inch to two miles, i.e. one inch on the map represents two miles on the ground measured in the same units. As the unit on both the sides of ratio must be the same, you have to convert two miles into inches,

$\because$ 1 mile = 63,360 inches

$\therefore$ 2 miles = $2 \times 63{,}360$ = 126,720 inches

i.e. 1 inch on the map represents 126,720 inches on the ground.

Now, the R.F. is always expressed in terms of a fraction in which the numerator is one.

$$\therefore \text{R.F.} = \frac{\text{Distance on the map}}{\text{Distance on the ground}}$$

$$= \frac{1}{126{,}720}$$

$$\text{or} \quad 1 : 126{,}720$$

3. The scale of an Indian map is one centimetre to ten kilometres. Convert this scale into the British system of units.

The scale of the Indian map is one centimetre to ten kilometres, i.e. one centimetre on the map represents 10 kilometres or $10 \times 100{,}000$ centimetres on the ground

$$\therefore \text{R.F.} = \frac{1}{1{,}000{,}000} \text{ or } 1 : 1{,}000{,}000$$

Conversion of the R.F., 1 : 1,000,000, into British system means that 1 inch on the map represents 1,000,000 inches on the ground.

$\because$ 1 mile = 63,360 inches

$\therefore$ 1 inch on the map represents $\frac{1{,}000{,}000}{63{,}360}$ miles on the ground

= 15.78 miles on the ground.

Hence, the scale of the map in the British system of measurement is one inch to 15.78 miles or one inch to 15.8 miles or even 1 miles approximately.

(iii) *By Graphical Section*—This is also known as a plain or a linear scale. This is merely a straight line divided at certain intervals, so that the distances on the map can be easily measured with the help of a scale in terms of distances on the ground. This scale has the advantage of remaining true even after enlargement or reduction of a map by photography. However, this method has also certain limitations as it is useful only to those who are familiar with the particular unit of measurement. So two scales are often shown, say kilometres and miles.

In constructing a graphical scale, a straight line of convenient length is drawn, so that the distances on the map can be easily read. The line is usually about 12 to 20 centimetres (or 5 to 9 inches) in length. The units should be shown in round numbers either in kilometres or in miles The divisions are usually in multiples of tens so that further sub-divisions, if necessary, are possible. For convenience, the primary divisions are shown on the right hand side of zero while secondary divisions (sub-divisions of the primary divisions) are marked off to the left of the zero mark (Fig 1).

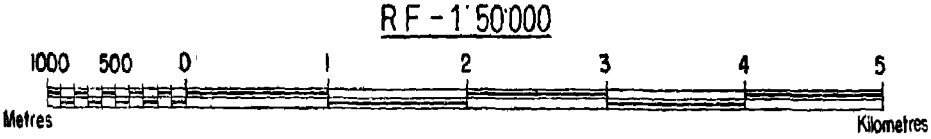

Fig. 1. Linear Scale

Example

The R.F. of a map is 1/633,600. Construct a graphical scale with primary and secondary divisions to read up to two kilometres.

R.F. $= \frac{1}{633,600}$, i.e. one unit on the map represents 633,600 units on the ground.

As one centimetre on the map represents 633,600 centimetres, i e. $\frac{633,600}{10,000} = 6,336$ kilometres on the ground, the scale of the map is 1 cm to 6.336 km.

As stated above, the convenient linear scale-line is usually between 12 and 20 cm in length. Supposing the length of the scale-line is 12 cm, it will represent 12×6.336 km$=76.032$ km.

This is an odd number and not convenient for the construction of a scale. Therefore, take a round number nearest to 76.032, say 80.

Now, to construct a linear scale for 80 km we must determine how many centimetres will represent 80 km

6.336 km are represented by 1 cm.

$\therefore$ 80 km are represented by $\frac{1 \times 80}{6.336}$

$=12.56$ cm.

or 12.6 cm approximately.

Linear Scale

Draw a straight line AB, 12.6 cm in length. From A draw another line AC making a convenient acute angle BAC. On AC, mark off twelve equal divisions (a, b, c, d, e, f, g . . . l) by means of a pair of dividers. Join the last point l to B and from the other points (a, b, c, d, e, f . . l) draw lines parallel to lB to meet the line AB. These parallel lines will cut AB into twelve divisions, each being equal to 10 km. These are the primary divisions (Fig. 2).

To obtain the secondary divisions, sub-divide the first primary division, i e. the division on the extreme left, into five equal parts as shown in figure 2. Each of these secondary divisions will represent two kilometres.

While numbering the scale, zero should be marked after one interval from the left, so that the left-hand end of the line can be numbered 10 and the primary divisions to the right of zero can have numbers 10, 20, 30, 40, 50, 60 and 70. This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale. This eliminates the need to sub-divide all the primary divisions of the scale,

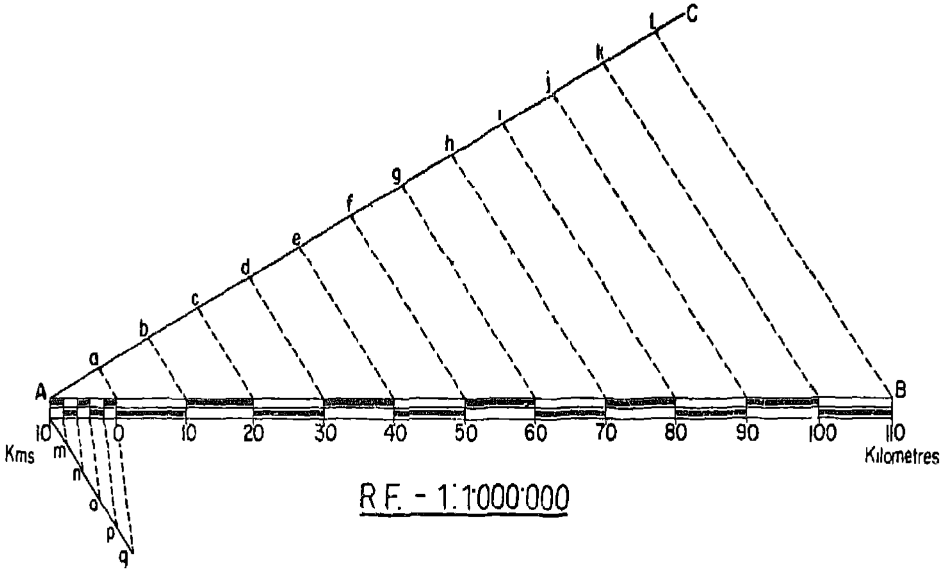

Fig. 2 Construction of Linear Scale

Diagonal Scale

Besides giving primary and secondary divisions, a diagonal scale gives divisions which are smaller than secondary divisions. In a way, this scale is an elaboration of the graphical scale and brings considerable precision in map-making. Figure 3 illustrates a diagonal scale by which we can read up to one-fiftieth of a centimetre If we take a line only one centimetre long instead of two, we may be able to read up to one-hundredth of a centimetre.

Draw a line AB equal to two centimetres in length. Draw AC and BD perpendicular to AB. On AC and BD mark off ten equal divisions of

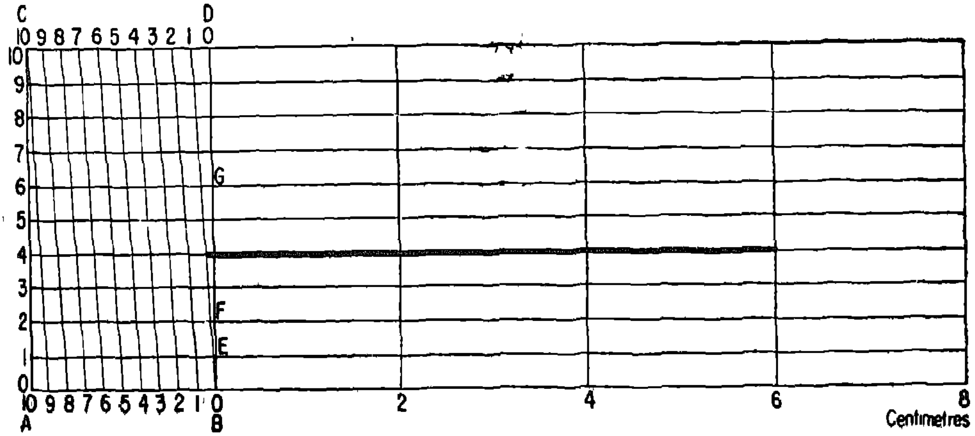

Fig. 3. Construction of Diagonal Scale

any convenient length and join the corresponding points of AC and BD by lines parallel to AB. Again, divide lines AB and CD into ten equal divisions each equal to 0.2 cm and mark them as 0, 1, 2, ... and 10 from right to left as shown in Fig 3 Now join 0 of line AB to 1 of line CD, 1 of line AB to 2 of line CD, and so on, as shown in the figure

In this figure each division along the lines AB and CD is equal to 0.2 cm Now, take into consideration the small divisions obtaining to the right of the diagonal line 01. One space up the line AB, the distance between the diagonal line 01 and E is 0.02 cm, two spaces up the line AB at F it is 0.04 cm, six spaces up the line AB at G it is 0.12 cm, and so on.

Suppose, you want to measure a distance of 3.08 cm. You may just have to add the distance between the diagonal line 0 01 and 1 (four spaces up the line AB) to three centimetres.

This is a very effective way of dividing a very short line into any number of parts, but it must be remembered that the parallel lines, the perpendiculars and the diagonals must be drawn with accuracy.

Measurement of an Area

For detailed map study, it is sometimes necessary and also useful to measure the area of any feature shown on a map (Fig 4). The area of a plot with regular sides can be calculated mathematically. But the features shown on a

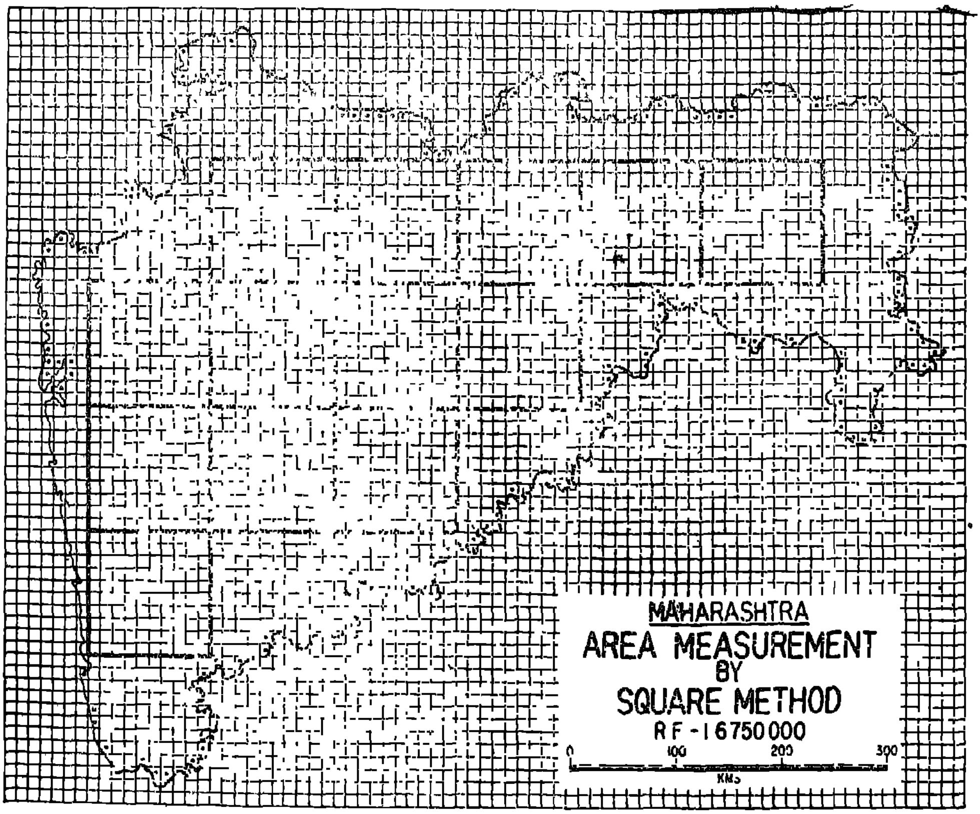

Fig. 4. Area Measurement by Square Method

map do not necessarily have regular sides, and this makes the calculation laborious. One of the simplest, but not very accurate, methods to calculate the area of such features is by means of squares. In this method, the feature shown on the map is covered with a tracing paper on which squares are drawn. Graph papers can be readily used in case they are of tracing paper type. A tracing table with lighting arrangement would be helpful in counting the squares.

To calculate the area, first count the number of complete big squares, then the number of complete small squares which are within the boundary. For small incomplete squares, count as one each of those which are more than half within the boundary and ignore those which are less than half within.

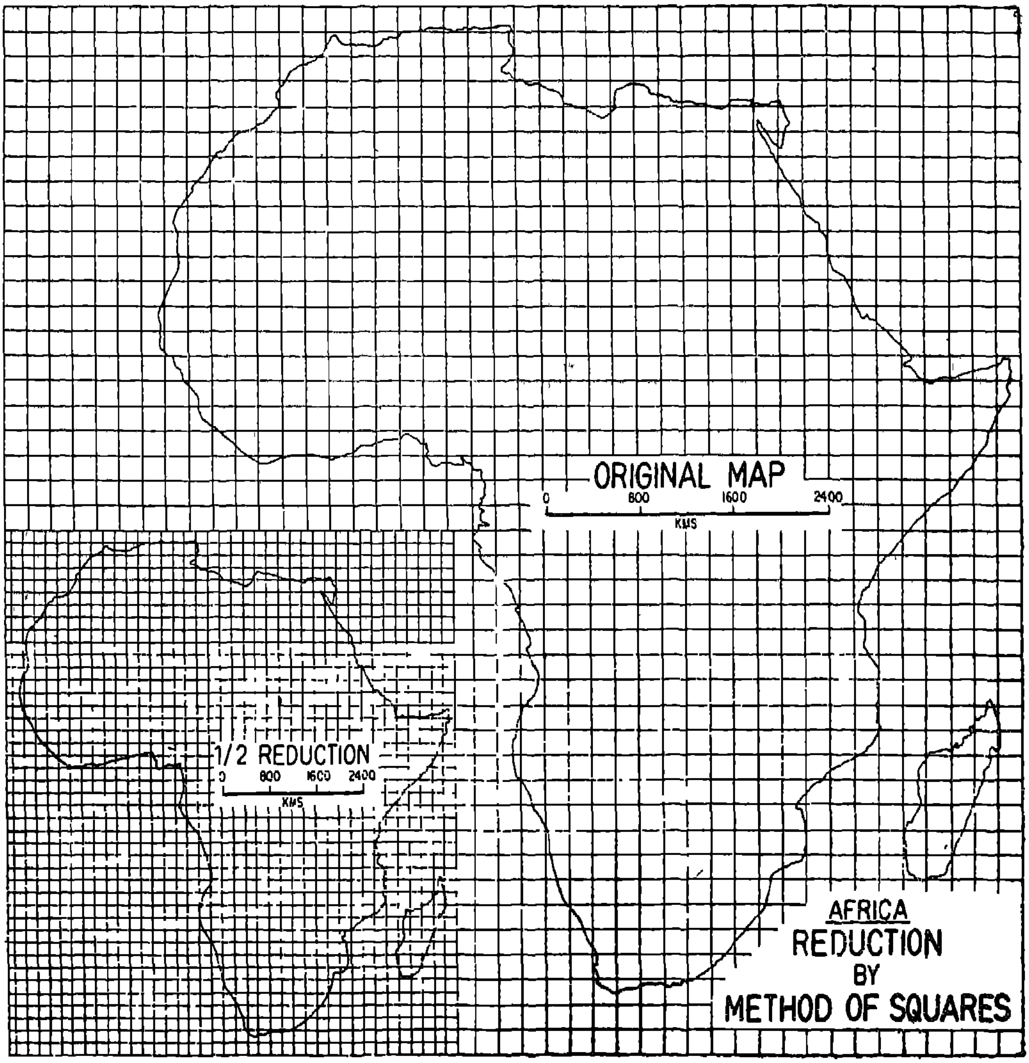

Fig 5. Reduction by Method of Squares

Enlargement and Reduction

Often a map of an area may be required in different sizes (Fig. 5). For instance, a map of a city may be needed at very large scale for town planning, at medium scale for tourist purposes, and at small scale for a textbook. This means that the scale of the map would also undergo changes either due to enlargement or reduction of the same map. This can be done directly by means of an instrument called pantograph.

Photographic method is the most accurate and quick method. But graphical method is the simplest one. It involves the use of a network of squares. The map to be enlarged or reduced is covered by a network of squares of any convenient unit On another sheet of paper, a similar network of squares is drawn in which the squares are reduced or enlarged according to the desired scale. The details, as shown on the map, are then carefully transferred according to their position on the two square sheets, noting particularly any important intersection of details with the grid lines. By this means, the map is reduced or enlarged, and the scale of the map is worked out by measuring the length of the side of the squares in both the sheets.

Suppose, the map is to be reduced to half its original size. A network of squares is drawn, each side measuring one centimetre to cover the entire map. Sub-divisions of each of the squares into convenient units are also marked off. On another sheet of paper similar squares with half the sides of the original square, i.e. 0.5 cm length are drawn. The squares are then divided into the same number of sub-divisions, i.e. smaller squares as in the first sheet of paper. In this network, the details of the map are transferred at the appropriate positions as shown on the original square sheet. The closer of the grid, the more accurate will be the result. In this method, you have only to find out the length of the side of required square on the new scale. The formula for calculating the size is:

$$X = \frac{\text{New Scale}}{\text{Old Scale}}$$

Example

A map to be reduced has the R F. $\frac{1}{50{,}000}$.

The R.F. of the new map will be $\frac{1}{250{,}000}$.

What is the proportion of reduction ?

The new scale is $\frac{1}{250{,}000}$

The old scale is $\frac{1}{50{,}000}$

$$\therefore\ X = \frac{\text{New Scale}}{\text{Old Scale}}$$

$$= \frac{\frac{1}{250{,}000}}{\frac{1}{50{,}000}}$$

$$= \frac{1}{250{,}000} \times \frac{50{,}000}{1}$$

$$= \frac{1}{5}.$$

Hence, the reduction is one-fifth, i e. the original map is reduced by five times.

EXERCISES

1. Answer the following questions :
   (a) What is a map ? Why is it called the basic tool of geography ?
   (b) What is scale ? What purpose does it serve on a map ?
   (c) What are the factors that govern the choice of scale ?
2. Write short notes on .
   (a) R.F.
   (b) Diagonal scale.
3. What are the different ways of **expressing** scales ? Illustrate your answer **with suitable**

examples to bring out the merits of each method.

4. Fill in the blanks, keeping in view the corresponding figures given in the other columns.

	Actual distance	*Map distance*	*R.F.*
(a)	4 km	4 cm	—
(b)	1 mile	—	1/63,360
(c)		6 cm	1/50,000

5. Make out correct pairs from the two columns given below.

	Distance to be shown	*Appropriate scale to be used*
(a)	80 km	Linear scale with primary and secondary divisions
(b)	3 miles 6 furlongs	Diagonal scale
(c)	6.56 cm	Simple linear scale

6. Complete the following statement by choosing a correct ending. The R.F. is a convenient scale with a universal application because :
   (a) it does not require linear or graphical scale.
   (b) it remains true even after reduction or enlargement of a map.
   (c) it is independent of any particular unit of measurement.
   (d) it makes it easy to measure directly the distances on the map.
7. Find out the R.F. of one-inch, half-inch, and quarter-inch toposheets. Work out the statements of scale for each one of them in centimetres to kilometres.
8. From an outline map of Andhra Pradesh :
   (a) Calculate the area of the state by the method of squares
   (b) Enlarge the map to double its scale.
   (c) Reduce the map to half its scale.
   (d) Prepare a linear scale with suitable primary and secondary divisions in kilometres for each map.

MAP PROJECTIONS

The earth being spherical in shape, a globe is its most satisfactory representation. However, maps are preferable for many purposes. Maps can be easily handled, they can be incorporated in books, or bound in atlases. Maps can be drawn to any scale and can be made to represent either the whole earth, or only a part of it, big or small. A map can be made to show a large number of details which a globe may not normally be able to represent.

Unlike a globe, which is three dimensional like the earth, a map is a two-dimensional device which attempts to represent only the surface features of the earth that is peeled, as it were, from the curved surface of the sphere and placed on a flat surface. It must, however, be borne in mind that no effort or device can entirely and smoothly flatten such a curved surface. Furthermore, when much flattening occurs, the geographic relationships shown on such a surface are bound to be distorted.

The important geographic relationships are : (i) shapes of landmasses, water bodies, or political units, (ii) their areas, (iii) distances between places, (iv) directions of any given place in relation to any other, and (v) locations of places or areas in relation to the entire earth.

Developable and Non-developable Surfaces

A developable surface is one that can be opened out to form a flat plane, or it is a surface which can be covered with a sheet of paper without the formation of folds and creases. A cylinder, a cone and a plane are three such surfaces.

A sphere has a non-developable surface. It is impossible, therefore, to transfer accurately the features from a sphere on to the plane of a paper Whatever method is adopted, it is bound to be inaccurate in one way or the other.

Thus, by the very basic limitations of maps, it is impossible for any map of the earth to show the correct shape or form of land and water bodies Moreover, it cannot be equally accurate with respect to area, location and direction, and at the same time show all the world on one continuous sheet without distortion.

For these reasons, the cartographers, whose job is to prepare maps as accurately as possible, have devised certain methods which make it possible to retain with precision at least one or more of these relationships while transferring geographic features from the spherical surface to a flat sheet.

The basic geographic fact about any feature is its exact position or location on the earth's surface. The position of any point on the earth's surface can be precisely defined with reference to a parallel of latitude and a meridian of longitude, just as on a graph where a point is located with reference to x and y co-ordinates from an origin. Therefore, basic to any map is the principle according to which a network of these parallels and meridians is transferred or projected from a spherical surface to a flat one.

The method by which the network of parallels and meridians called the earth's grid is transferred or projected from the spherical surface to the plane of a paper is technically known as a map projection. A map projection attempts to transfer, graticule by graticule, the features from the spherical earth to the plane of a sheet of paper. The term "graticule" is adopted for any area bounded by two parallels of latitude and two meridians of longitude.

Since no map projection can be correct in all respects, the choice of a map projection always depends upon the purpose for which the map is to be drawn. This is particularly true when we have to draw maps for large areas such as countries, continents, hemispheres, or the earth as a whole. For this purpose we shall study some major projections.

Classification of Map Projections

The classification of map projections according to their major characteristics, such as preservation of either area, or shape, or direction, therefore, becomes very useful. Map projections are usually classified into four groups: (i) equidistant projections, (ii) equal area or homolographic projections, (iii) correct shape or orthomorphic projections, and (iv) true bearing or azimuthal projections.

(i) *Equidistant Projections*—It is impossible to represent at a consistent scale all distances of the sphere on a plane. In equidistant projections, emphasis is laid on retaining consistency of scale as far as possible. In these projections, the scale is maintained true in all directions from only one or two points such as the centre of the area mapped.

(ii) *Equal-area or Homolographic Projections*—In this group of projections, a grid is developed in such a way that every graticule or the network of latitudes and longitudes on the map is equal in area to the corresponding graticule on the sphere. The property of equal area is usually achieved at the cost of directions or true shapes.

(iii) *Correct Shape or Orthomorphic Projections*—In this class of projections, every care is taken to preserve shapes. This involves changing the scale from point to point. Parallels and meridians cut each other at right angles and proper relationship between their lengths on the map and those on the globe is maintained. A constant ratio between the scales at any point is also maintained. It may be noticed that the scale ratio does not remain constant at every point

(iv) *True Bearing or Azimuthal Projections*—In these projections, correct bearings or azimuths, i.e. directions, are preserved.

Just as map projections can be classified according to their major characteristics or properties, they can also be classified on the basis of their construction. The ease with which a map grid can be developed is also an important consideration in selecting a map projection. The graticule on the sphere cannot be transferred satisfactorily on to the flat surface direct in a single operation. Usually, they are first transferred on developable surfaces. Thus, we have another system of classifying projections on the basis of the actual process of projecting the globe over a plane surface.

Projection of Earth's Grid

The earth's grid is projected in three ways : (i) on a cylinder, (ii) on a cone, and (iii) on a plane. These projections are called cylindrical, conical and zenithal respectively.

(i) *Cylindrical Projections*—In these projections, a cylinder is presumed to have enveloped or cut the globe in a particular manner. A cylinder on which the globe is projected is cut open along a line running from the base to the apex and unfolded A cylinder thus developed becomes a rectangle.

Simple Cylindrical Projection (Cylindrical Equidistant)—Let us suppose that a cylinder of tracing paper envelopes the globe touching it along the equator. On this paper cylinder the equator bears the same length as it has on the globe. The equator and other parallels of latitude are projected as circles. This cylinder is afterwards cut along a convenient line parallel to the axis and unfolded into a flat surface The parallels of latitude become a series of straight lines, all of equal length and parallel to the equator.

Again, along the equator, if the points of intersections of meridians, which are evenly spaced, are first pencilled in on the paper cylinder and then opened out, perpendicular lines drawn through these points will represent meridians of longitude. The meridians of longitude thus derived become a series of parallel straight lines, all of equal length and always

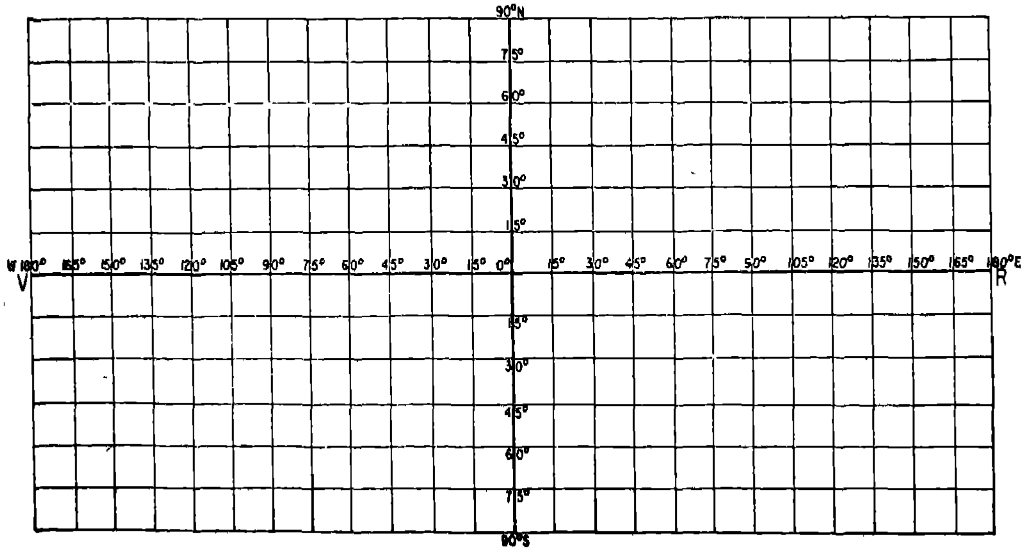

Fig. 6. Simple Cylindrical Projection

spaced evenly, cutting the equator and all the parallels at right angles.

Example

Construct a simple cylindrical projection for the world map showing latitudes and longitudes at intervals of 15°, the radius of the reduced earth being five centimetres (Fig. 6).

The formula for finding out the circumference of the earth along the equator is $2\pi r$ where π is equal to 3.1416 or nearly $\frac{22}{7}$ and r is the radius of the reduced earth, i.e. five centimetres.

The length of the equator

$$= 2\,\pi\, r$$

$$= 2 \times \left(\frac{22}{7}\right) \times 5$$

$$= 31.42 \text{ or } 31.4 \text{ cm approx.}$$

Draw a straight line VR representing the equator equal to 31 42 cm. As the meridians are to be drawn at 15° intervals, divide VR into 24 equal parts Through these points, spaced at equal intervals (15°) along the equator, draw meridians as straight lines perpendicular to the equator and let NS be the central meridian. Any meridian, whatever its value, when it stands at the centre of the projection, is called the central meridian Obviously, it has nothing to do with the Prime Meridian or the Greenwich Meridian

To obtain other parallels of latitude at 15° intervals, mark off the same intercept distance by as many points as are necessary along NS to the north and south of the equator. Through these points draw lines parallel and equal to the equator. Thus, a simple cylindrical graticule is obtained.

The same result can be obtained by another method. Describe a circle with centre O and radius equal to 5 centimetres to represent the reduced earth. Let EOE′ be the equatorial diameter. Since the parallels of latitude and meridians of longitude are to be drawn at 15° interval, mark off an angle of 15° from the centre O, and join O to the point obtained to meet the circle at a.

Draw a straight line, 31.4 cm in length, to represent the equator showing the range of 360° of longitude. To get an interval of 15°, divide it into 24 equal parts. Through these points, spaced at equal intervals, i.e. at 15° along the equator, draw meridians as straight lines perpendicular to the equator and let NS be the central meridian.

To obtain the other parallels of latitude, mark off starting from the equator distances equal to the length of the arc EA, six times to the north and south of the equator along NS. Through these points draw lines parallel and equal to the equator. These lines will represent the parallels of latitude and a network for the world map is produced. Number the parallels and meridians as shown in Fig. 7.

The distance along a parallel of latitude, which is measured between two meridians, varies in different map projections In the simple cylindrical projection, it is correct only along the equator and is exaggerated to the north and south; the exaggeration tending to become infinite towards the poles, where a point is projected as a straight line equal in length to the equator.

The distance along a meridian of longitude which is measured between two parallels of latitude also varies with different map projections.

In this projection, parallels and meridians cut each other at right angles. Hence, a cylindrical, equidistant projection is rectangular in shape. All the parallels are equal to the equator and all the meridians are half of the equator in length. It is not an equal-area projection.

This projection does not maintain correct shape and hence it is not orthomorphic. Owing to the exaggeration of the scale in the higher latitudes, the shapes of the continents are highly distorted and, therefore, the projection is not useful for middle and higher latitudes. It is more suitable for mapping the areas in low latitudes, i.e. equatorial regions.

Cylindrical Equal-area Projection—Like the simple cylindrical, this projection is also developed by projecting the globe on a cylinder which is tangential at the equator. The cylinder is then spread out flat as a rectangle. In this projection also, the scale along the parallels becomes increasingly exaggerated, but at the same time the scale along the meridians diminishes progressively towards the poles. Because of this characteristic the projection acquires to a large extent the equal-area property.

Example

Construct a cylindrical equal-area projection for the world map showing latitudes and longitudes at intervals of 15°, the radius of the reduced earth being five centimetres (Fig. 7).

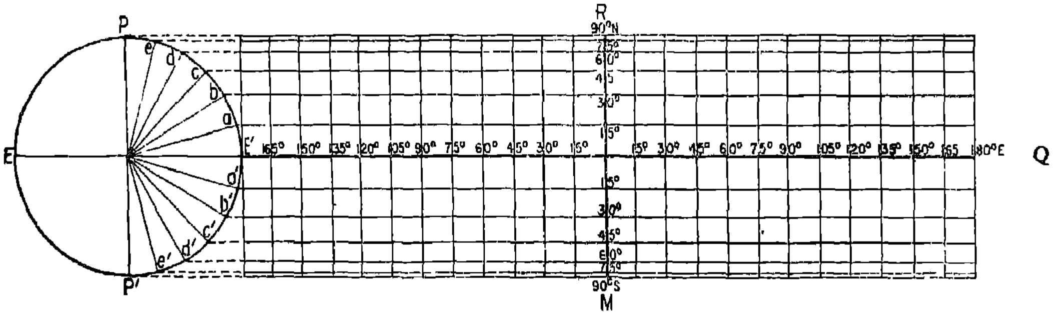

Fig. 7. Cylindrical Equal Area Projection

Draw a circle with a radius of five centimetres to represent the reduced earth. Let EOE' and POP' be the planes of the equator and polar axis respectively. Lay off at the centre of the circle angles at 15° intervals in order to get the latitudes of 15°, 30°, 45°, 60°, 75°, and 90°. Let the positions of these latitudes on the circumference be a, b, c, d, e, and p, and a', b', c', d', e', and p'.

Produce EOE' to Q making E'Q equal to the true length of the equator, i.e $2\pi r$ where r is five centimetres, Through the points a, b, c, d, e and p and also a', b', c', d', e' and p' draw lines parallel to the equator and of the same length as the equator. These are the parallels of latitude.

Divide E'Q into 24 equal parts as the meridians are at 15° intervals, and draw meridians through these points cutting the equator at right angles. MR is the Central meridian. This will give a cylindrical equal-area network for the world map.

In this projection, the scale is correct only along the equator. It gets exaggerated towards north and south, the exaggeration reaching infinity at the poles, where a point is projected as a straight line. In other words, all parallels are projected equal in length to the equator.

The scale along the meridians is not correct throughout as it decreases towards the poles. The scale from north to south becomes reduced in exactly the same proportion as the scale from west to east becomes enlarged. Hence, the equal-area property is preserved. The meridians intersect the parallels at right angles.

The area is represented accurately in this projection, but it is not an orthomorphic projection. Because of excessive distortion of shape in high latitudes, this projection is not widely used for maps of the whole globe. The utility of this projection is limited to the representation of countries adjoining the equator. It is sometimes used for world maps showing the distribution of rice, tropical forests etc.

(ii) *Conical Projections*—In these projections, it is supposed that a simple cone rests on a globe in a particular manner. When the cone is cut open along a line running from the base to the apex and flattened, it becomes the sector of a circle

The cone may be regarded as either touching or intersecting the globe. Many graticules can be devised in this group, the most elementary being the simple conical projection with one standard parallel which is easy to draw and is commonly used. The construction of this projection is described below.

Suppose a tracing paper cone, whose apex is directly above the pole of the globe, is placed tangential to the globe along any chosen parallel of latitude. This chosen parallel of latitude is called the standard parallel.

When the cone is developed, the parallel along which the cone is touching the globe becomes an arc of a circle. Here, radius is equal to the slant height of the cone, and the centre represents the apex of the cone.

The parallels and the meridians are transferred to the surface of the paper cone and the cone is cut open to make it flat The meridians on this flat surface become straight lines radiating from the centre, i.e. the apex of the cone, at uniform angular intervals. The parallels of latitude will now be arcs of circles described about the same centre to which the meridians converge. The meridians will intersect the parallels at right angles.

The standard parallel is true to scale and all other parallels are spaced at their true distances from the standard parallel to the north and south of it. A central meridian is drawn to represent the meridian which passes through the centre of the country to be mapped.

Example

Construct a simple conical projection with one standard parallel at 50° N for a reduced earth of radius five centimetres to show lines of latitude and longitude for the range 0° to 90° N and 30° E to 130° E at intervals of 10° (Fig. 8).

The standard parallel is 50° N. The central meridian will be 80° E, i e. midway between 30° E and 130° E.

With O as centre and radius five centimetres describe a circle PEP'E' to represent the reduced earth. Draw EOE' to represent the equatorial diameter and POP' the polar axis. Measure the angles AOE and BOE″ of 50° each to get AB, the standard parallel of 50° N. At A and B draw tangents to meet the produced polar axis at X, the apex of the cone. Now XA or XB is the radius of the 50° N parallel in the projection.

Take any line TS as the central meridian, i.e. 80° E. With a radius equal to XA or XB and the centre at T, draw an arc MLK to represent the standard parallel. On the reduced earth, PEP'E', make an angle EOF equal to 10°, the given interval between the parallels of latitude. Now, the distance along the arc EF is the true

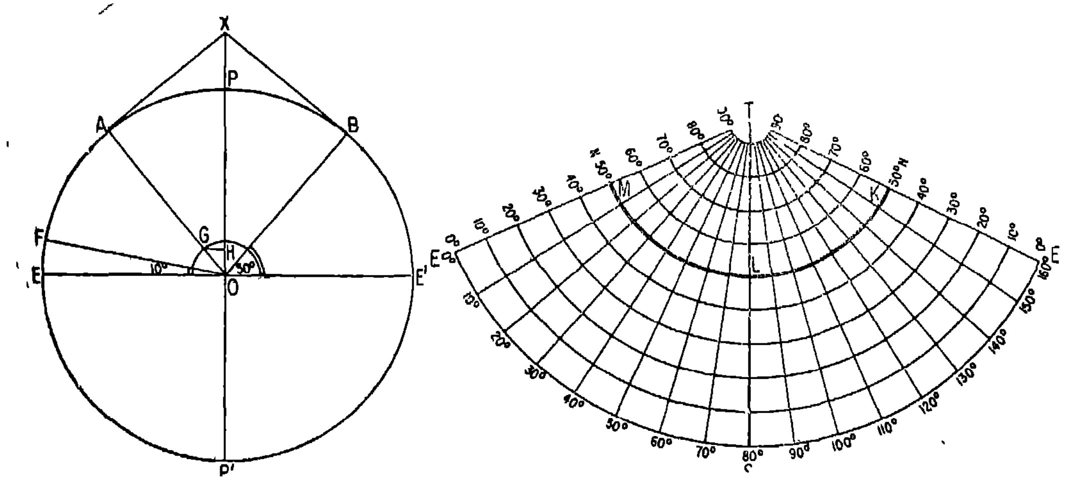

Fig. 8. Simple Conical Projection with One Standard Parallel

distance between two parallels at 10° interval. With the distance equal to arc EF, mark off as many points as are necessary along the central meridian to the north and south of the standard parallel. In this case, you may need to mark off four to the north to show 60°, 70°, 80° and 90° and five to the south to show 40°, 30°, 20°, 10° and 0° parallels. With T as centre, draw arcs of circles through these points. These will represent the parallels of latitude from 0° to 90° N.

On EOE', with O as centre and arc EF as radius, describe a semicircle. This semicircle intersects OA at point H. Thus, OH is the longitudinal distance between two meridians 10° apart on the standard parallel. On the projection, mark off divisions equal to the length of the perpendicular OH. These should be five on either side along the standard parallel and on either side of the central meridian. Draw the meridians by joining these points to T. They will cut all the parallels at right angles. This will give a network of parallels of latitude between 0° to 90° N and meridians of longitude between 30° E to 130° E.

In this projection, the parallel scale is correct only along the standard parallel, whereas it is exaggerated to the north and south of the parallel. The exaggeration increases as the distance from the standard parallel increases The pole, which is actually a point on the globe, is represented by an arc of a circle at its true distance from the standard parallel. The parallels and meridians cut each other at right angles, and the meridian scale is correct everywhere.

This projection is neither equal-area nor orthomorphic. It is not suitable for an area which covers more than 20° of latitude, but is fairly accurate for narrow latitudinal zones lying in mid latitudes with any extent of longitude.

(iii) *Zenithal Projections*—In such projections, the parallels and meridians of the reduced earth are projected on to a plane which is tangential to the globe. The plane touches the reduced earth at one point which is the centre of the projection. The simplest cases of these projections are those in which one of the poles is the centre. All zenithals possess the property of maintaining correct azimuths or true bearings from the centre of the projection. Hence, they are also known as azimuthal projections.

In Zenithal Equidistant Projection—directions or distances from a particular point are of special interest. In this projection, the direction of any point from the centre is true. Likewise, the distance of each point from the centre is also true as these are equidistant from it. In Zenithal equal-area projection, parallels are not drawn at their true distances apart. Distances decrease between two parallels outwardly. The rapid increase in distances along the parallels away from the centre is countered by bringing meridians closer. Thus the area remains correct.

Example

Draw a zenithal equal-area projection for a reduced earth of five centimetres for the eastern half of the northern hemisphere showing latitudes 0° to 90° N and longitudes 0° to 180° E at intervals of 15° (Fig. 9).

With O as centre and radius equal to five centimetres, describe a circle representing the reduced earth. Let EOE' and POP' be the equatorial diameter and the polar axis respectively. From the centre, on EO, measure off angles of 15°, 30°, 45°, 60°, and 75° these lines meeting the circumference at a, b, c, d and e respectively.

On the projection, draw a vertical straight line. Let the point P be the centre of this line representing the North Pole. Through this point, draw meridians from 0° to 180° as radiating lines at intervals of 15°. From the reduced earth measure off arc distances PE, Pa, Pb, Pc, etc. and with centre P describe arcs of the concentric circles representing the parallels of latitude PE for 0°, Pa for 15°, etc. from 0° to 90° N.

The parallel scale is not correct as it increases somewhat rapidly away from the centre. The meridian scale is correct throughout. Every

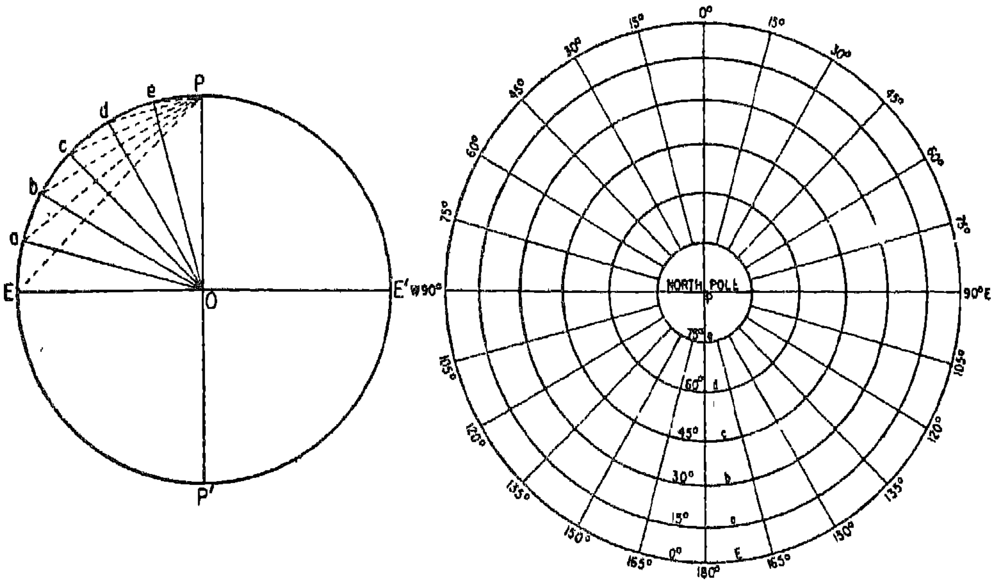

Fig. 9. Zenithal equal-area Projection

point is at its true distance and in the right direction from the centre. The projection is equal-area. It is the most commonly used projection for the polar areas. As the shape is somewhat distorted away from the centre towards the periphery at a uniform rate, it is suitable only for small areas around the pole, not exceeding about 30° in latitudinal extent

Choice of Projections

Selection of a projection of any map depends upon several factors. The purpose for which the map is to be drawn is obviously the first consideration Moreover, the position of the area to be mapped, its latitudinal and longitudinal extent, and the ease with which a projection may be drawn are some of the other factors that influence the choice of a projection.

For drawing maps of small countries like Sri Lanka, Nepal, Cuba, Portugal or France, a projection like the simple conical is found suitable. A simple conical projection with one standard parallel may be useful in the case of countries like Nepal whose latitudinal extent is not much, and for countries like the Union of Soviet Socialist Republics which has a vast extent of longitude. On the other hand, a simple conical projection with two standard parallels may be found more suitable for countries like Sri Lanka, Portugal, France, the United States of America and the Soviet Union whose latitudinal extent is slightly more. Conical projection is suitable for India. These projections can be used for maps showing political units, physical features or distribution of crops and commodities.

For maps of the polar regions, the zenithal projection(s) are perhaps the most convenient. These projections show correctly the distances along the meridians, the directions from the pole and equal-area around it.

For a world map, the cylindrical equal-area projection is commonly used. On this projection, the area is everywhere true to scale as compared with the globe. However, the shape of the countries in high latitudes gets much distorted although the distortion within the tropics is little. Because of these properties, the projection is suitable for showing distribution of products such as rice, sugarcane or rubber grown in the tropics. This projection is popular because it is easy to construct.

EXERCISES

1. Answer the following questions :
   - (a) How does a map differ from the globe ?
   - (b) What is a map projection ?
   - (c) Which are the important geographical relationships that one looks for in a map ?
   - (d) Why is the earths's surface said to be non-developable ?
   - (e) List the basic limitations from which a map may suffer.
2. What do you understand by (a) Developable surfaces, (b) Central meridian, and (c) Zenithal projection. Write about five lines for each.
3. Write in about 30 lines the need for map projection and the classification of projections according to their use and method of construction.
4. What are the factors that govern the choice of projection ? Give specific examples wherever you can.
5. Use one term to describe each of the following statements.
   - (a) The network of parallels and meridians.
   - (b) An area bounded by two parallels of latitude and meridians of longitude.
   - (c) A method of transferring the earth's grid to a plane surface.
   - (d) The distance along a meridian of longitude measured between two parallels.
   - (e) A plane passing through the centre of a sphere dividing it into halves.
6. Construct the following projections as explained in the text.
   - (a) Simple cylindrical projection.
   - (b) Cylindrical equal-area projection.
   - (c) Simple conical projection with one standard parallel.
   - **(d) Zenithal equal-area projection.**

SURVEYING

Surveying is the art of making observations both linear and angular in order to determine the relative position of the places or objects on the surface of the earth. Surveying helps us to prepare a map of any big or small area. It is useful in preparing the layout plans of roads, railways, buildings and multi-purpose projects. Field boundaries of agricultural lands, demarcation of forest areas, and other land uses can also be demarcated through surveying. Development of existing towns or establishment of new towns also needs surveying. With advances in science and technology, the art of surveying has become highly technical and specialised. At the same time, it has increased in efficiency and accuracy.

For the geographer, surveying as an art is necessary in conducting local surveys. Often maps for small areas do not exist In such cases, the geographer is required to study the area carefully and plot his observations in the form of a map. A knowledge of the art of surveying helps one in map-making, particularly in the preparation of topographical maps. These are, by and large, the important maps which the geographer uses in studying the patterns of distribution of various features on the earth's surface.

Methods of Surveying

A surveyor uses different kinds of instruments, depending upon the nature of the survey. Here, we shall illustrate the methods of surveying using (i) chain and tape, (ii) plane table, and (iii) the prismatic compass.

(i) *Chain and Tape Survey*—The chain is one of the important tools in surveying, particularly in the survey of small areas such as boundaries of land holdings, roads, canals, etc However, compared to highly technical methods employed in surveying, chain survey is an elementary and time consuming method. It is, nevertheless, the essential step in getting acquainted with map-making and in the study of distribution of different features of the geographical landscape.

The survey chain is a device for measuring distances between two different objects (Fig. 10). It is made of mild steel wire and has brass handles at both ends, so that it can be pulled easily. The chain may be of different lengths. It has fixed number of links, each one consisting of one or three small rings at each end. The most commonly used chains come in two lengths: engineer's chain which is 100 feet in length, and Gunter's chain which is 66 feet long. Under the British system of units Gunter's chain was found to be convenient because 80 Gunter's chains make a mile and 10 square chains make an acre ($10 \times 66^2 =$ 43560 sq ft = 1 acre). In order to adapt to metric system of units, chains of 30 metres and 15 metres have come in use in our country They are similar to engineer's or Gunter's chain. For reading the number of links in a chain, tallies and small brass rings are provided at certain intervals.

Tallies are metallic tags or indicators of distinctive pattern attached to a chain at fixed points to facilitate the quick reading of fractions of a chain

The different patterns of tallies depend upon their positions in the chain. In a 30-metre chain, tallies at the end of five metres from either end of the chain have one tooth and indicate five metres from either end. The tallies at the end of ten metres have two teeth and indicate ten metres from either end. The central tag with distinct shape indicates 15 metres Thus, these tallies help us in measuring the distance from either end of the chain.

On the reverse side of the handle of the chain is mentioned the total length of a chain, viz. 15 metres or 30 metres as the case may be. A groove is cut on the outside surface of the handle to facilitate holding the arrows or chain pins in position with the handle of the chain. The radius of the groove corresponds to the radius of the arrows.

Tapes are available in various lengths or denominations. They are made of either linen or of metals like steel or brass. Of these, steel tapes are the best. Tapes of 15 metres length are common Tapes made according to Bri-

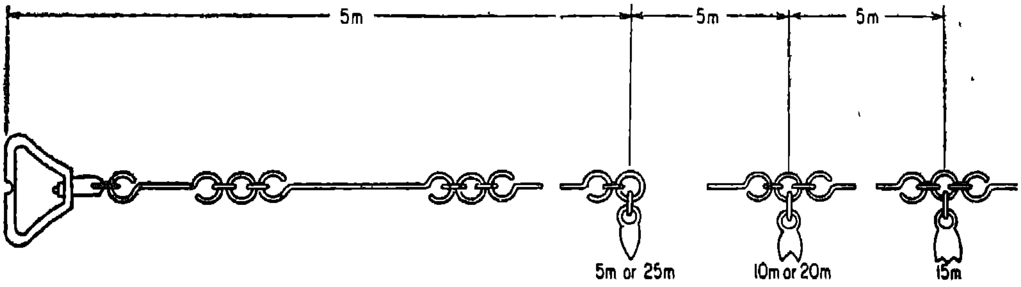

Fig. 10. Parts of the Surveyor's Chain

tish measures are also available in various denominations ranging from 3 feet to 100 feet. Among them, the tapes of 50 feet or 100 feet are common.

Ranging rods—These are usually made of wood, shod with iron to enable them to be fixed securely in the ground. They are generally six feet or two metres in length. Alternate feet are generally coloured in red and white, so that they may show up both against light and against a dark background. Sometimes, flags are attached at the top.

Arrows—Each chain is provided with ten arrows made of iron wire 35 to 45 cm long. These are well pointed at one end, so that they may be easily driven into the ground. The other end of the arrow is curled into a ring to serve as a handle. The arrows are used for counting the number of chain lengths in a line.

Besides these instruments, a magnetic compass and an optical square are used in chain survey. While the former helps to determine the north point, the latter is used for finding out the points on the chain line from which the objects to be plotted along the chain line are at right angles.

Procedure for chain survey—Before conducting any survey, you have to prepare a sketch of the area to be surveyed. This sketch need not be drawn to scale. It should be reasonably correct and should show the details in correct perspective. You should also bear in mind that the underlying principle in chain survey is to divide the area into suitable triangles whose sides can be measured in the field and that all distances are measured horizontally on a level plane (Fig 11).

For having such a suitable triangle, you must walk over the ground and ascertain that the points A, B and C of the proposed main triangle would be such that the triangle so formed would be as big as can be obtained on the ground. Its sides should be such that there shall be no obstruction in measuring distances accurately. Moreover, each side, as far as possible, should lie near a boundary or other objects to be plotted on the survey.

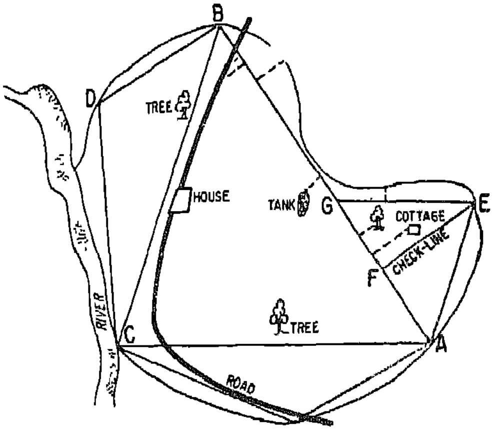

Fig. 11. Layout of Triangles for a Chain Survey

If the main triangle satisfies most of these conditions, the actual task of surveying would become easy as it permits a few more subsidiary triangles to be built on to it. It is further advisable to have a couple of check-lines as shown in Fig. 11 to find out errors, if any, in the measurements.

Once the plan is laid out and the ranging rods are fixed at their respective stations, A, B, C, etc., two persons are required to conduct the actual survey. One who goes ahead dragging the chain after him is called leader and the other, the follower. It is interesting to note that, like a good citizen, it is the duty of the follower not only to follow his leader but also to see that the leader keeps on a straight path in line with the ranging rod. The point from which the measurement begins is called the starting point and the other end of the straight line to be measured is the closing point.

The surveyors begin to operate according to plan when the follower holds the handle of the chain and stands over the station A, the starting point. The leader takes the other handle of the chain and ten arrows and proceeds in the direction of the closing point, i.e. station B.

When a chain length from the starting point is reached, the leader turns back and faces the follower to receive instructions from him to make sure that he is in line with the ranging rod at B The follower aligns the leader signalling him to move to the right or left by lifting up his right hand or left hand and the leader moves slowly in the direction indicated till the follower signals the leader down by putting down his hand. The position can be easily checked by the leader holding an arrow suspended from a handkerchief.

Having got into line, while the follower is holding the end of the chain firmly at the station, the leader lifts the chain, pulls it tight giving it a girth-wave motion with an up and down movement with the wrist of his hand. An arrow is fixed at the end of the chain.

Now, with the help of a tape, "offsets" are taken on either side of the chain line. An offset is a measurement taken at right angles to the chain line. Care is taken to see that the tape is held at right angles to the chain. An optical square is used for this purpose. It is used for setting out right angles for measuring short offsets from the chain line to any object nearby. Generally, offset readings are taken up to 15 metres or 50 feet on either side of the chain line When measuring corners of buildings, it is advisable to take two measurements to the same point from two different positions on the chain line, one of which may or may not be an offset.

After having completed the offset measurements along the chain line, the leader pulls the chain forward holding the handle leaving the arrow in position. The follower stations himself at the position of the first arrow and directs the leader, as before, in line with the station ahead and the same procedure is followed till they reach the closing point B of the chain line AB.

The follower goes on picking up the arrows and keeps them with him to know how many full chain lengths have been completed. The length of the chain line is determined from the number of arrows collected by the follower on his way plus the number of links of the last chain that remains incomplete at the closing point.

If the surveyors are using a chain with the metric system of units and the follower has picked up 6 arrows and the distance between the last arrow picked up and the closing point is 38 links the total length of the chain line will be 6×100+38=638 links.

Field notes—To enter the measurements, the the field book is marked with two lines, about a centimetre apart, down the middle of the page. This space within the two lines is meant for entering distances along the chain line which are entered upwards from the bottom of the page. The space on either side of the central column is meant for entering offsets so as to correspond with each side of the ground along the chain line (Fig. 12).

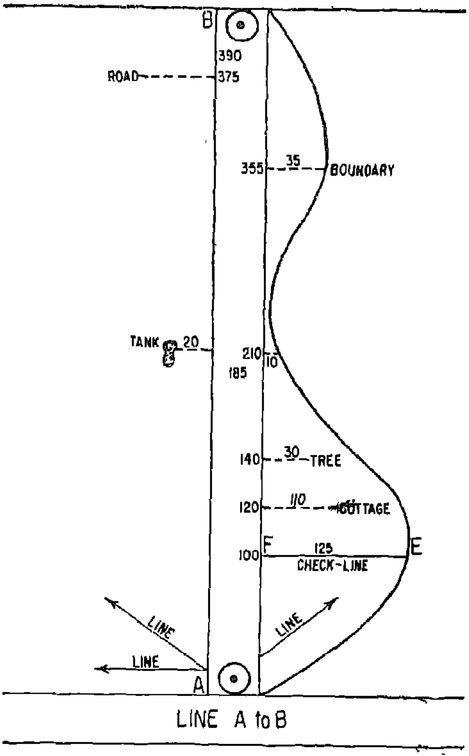

Fig 12. Field Book for Chain Survey

A sketch of the boundaries is made on the right or left side of the page depending upon its actual position in relation to the chain line. The offsets are also entered on this sketch either to the right or left of the central column, as the case may be At the bottom of the page the name of the line being surveyed is marked.

The primary object of keeping a neat field book is to ensure that the sketch and the measurements progress simultaneously, line by line, never allowing the sketch to get ahead of the measurements or *vice versa*.

Plotting the survey—The plan now to be plotted is a small representation of the important features of the area surveyed Before actual plotting, a suitable scale is chosen according to the size of the desired plan and the actual area surveyed When plotting the survey, a line to represent one of the longer sides of the triangles is first drawn on the paper according to the scale chosen and the other sides are drawn with reference to it.

The triangle ABC in Fig 11 is drawn as follows:

First, the line BC is drawn and then, with B as centre and BA as radius, a circle is drawn. Then, with C as centre and CA as radius, a second circle is drawn, which will cut the first circle at two points on either side of BC. The sketch must show which of these is the correct intersection to be chosen. After drawing all the triangles, the offsets from each chain length are marked according to scale and the whole plan is carefully completed with necessary details.

(ii) *Plane Table Survey*—To the student of geography, plane tabling is a highly useful fieldwork technique. It offers him an opportunity to draw a complete map while he is in the field. It provides him with the exciting experience of transforming a visible landscape into a map. A map drawn by this method is accurate and mistakes are rare because of the visible connection between the map and the landscape which could be easily tested while in the field.

A plane table consists of a table-top and a tripod, a sighting rule known as alidade, a spirit level, a trough compass, a plumb-bob, a chain, a tape, and a few ranging rods and wooden pegs (Fig 13).

A plane table is a light flat drawing board placed on a tripod. The board can be rotated, and fixed by means of a screw in any desired position in the horizontal plane. It is set horizontal with the help of a spirit level. A plumb

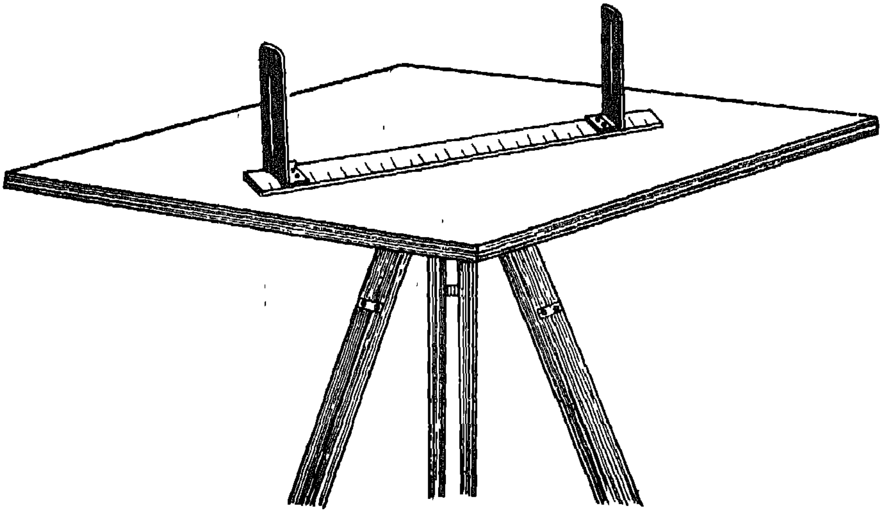

Fig. 13. Plane Table and Alidade

bob is used to centre the plane table over the spot marked on the ground.

The alidade is a strong flat ruler made of hard wood or metal. Its edges are perfectly straight and parallel. At each end it has flap sights which can be folded down when not in use. One of the flaps has a slit in the centre while the other has a vertical hair, wire, or thread. Directions on the plane table are obtained by sighting the object in the field so that the eye of the observer, the vertical slit and the thread line are all in a straight line with the object.

A trough compass consists of a magnetic needle on a pivot in an oblong box with parallel sides and a glass lid. It is used for drawing a north-south line on the paper.

Procedure for plane tabling—First, make sure that all parts of the plane table are in order. Mount carefully a drawing paper on the board. It is advisable to take a sheet of paper larger than the board so that it can be folded and pinned or pasted down below the board.

Choose two convenient stations, A and B, on the ground to be mapped, so that a line joining the two may serve as a base-line. The stations A and B should be so selected that it would be possible to sight from both of them all important landmarks and objects on the ground. Measure the distance between A and B by a chain.

On a convenient scale, draw the line AB on the paper mounted on the plane table. While choosing the scale, care must be taken to see that the area to be mapped is properly represented on the paper. Set the table as nearly horizontal as possible over the point A on the ground with the help of a plumb-bob. Place the alidade along the base-line AB drawn on the paper. Rotate the table-top round until the points A and B on the paper and the station B on the ground fall in one line. The table is then said to be oriented.* Clamp the board in this position and check the sight again.

With the help of the alidade sight the important objects from A on the paper. Draw every time a ray on the paper along the edge of the alidade. Label each ray with the description or name of the object which it points to. A sketch diagram may help in the identification of rays. Care may be taken to draw the rays long enough to cover the distance between the station and the object according to scale.

Once all the needed objects or landmarks are sighted from station A, shift the plane table to station B.

Ensure that the table-top is on a horizontal plane and the point B on the paper is exactly over station B on the ground. Orient the table in such a way that the line BA on paper is directed exactly towards station A on the ground while B on the paper is vertically over the station B. Repeat the whole work from station B by drawing rays in the same way to the objects observed from station A. While doing so, all the points will be fixed on paper by the intersection of rays drawn from points A and B. Complete the plan.

Finding directions—Distance and direction are the two fundamental components of surveying. After learning how to measure distances in the field, the next step would be to determine direction. No plan or survey is complete without showing the direction.

The four major cardinal points of direction are north, south, east and west. The directions are measured with respect to the north. The true north may be determined by different methods.

In the northern hemisphere, true north can be determined with the help of the Pole Star. A constellation of seven stars known as the

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* It must be remembered that so long as A was not at the centre of the table, its position would alter with the rotation of the table and will not be vertically over the station on the ground The error should not be large, and it can be corrected by shifting the paper slightly.

Great Bear can be recognised in the northern skies by its peculiar shape. The two stars in the front always point to the Pole Star. The Pole Star is located vertically above the North Pole (Fig. 14).

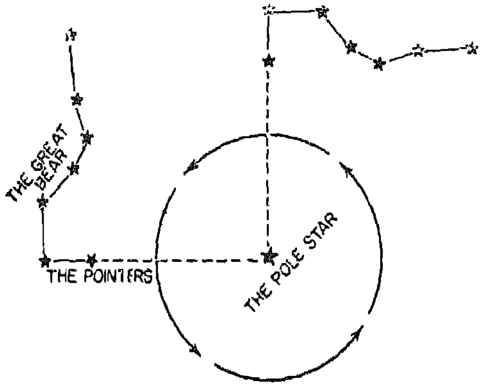

Fig. 14. The Pole Star and the Great Bear

This method is useful only in the northern hemisphere as the constellation is not visible in the southern skies. Obviously, this method is useful only at night.

The north can be determined with reference to the sun as well. Fix a rod vertically in the ground. Measure the length of the forenoon shadow. With the lower end of the rod as centre and this length of the shadow as radius draw a circle. The length of the shadow will decrease until mid-day and will increase until the sun sets. The shadow will again touch the circle in the afternoon. Bisect the angle between the forenoon shadow and the afternoon shadow. The bisector is the true north-south line (Fig. 15). This method is useful only at daytime and when the sky is free of clouds so that sunshine can reach the earth unobstructed.

A rough estimation of the direction of the true north can be obtained by means of an ordinary watch. In the northern hemisphere if the watch is held in a horizontal position and turned until its hour-hand points to the sun, the line that bisects the angle made by the hour-hand with the line joining 12'O clock with the centre of the watch will point to the south. A similar exercise in the southern hemisphere will indicate the true north. This is also a crude method dependent upon the sun (Fig. 16).

The most efficient way of finding the north

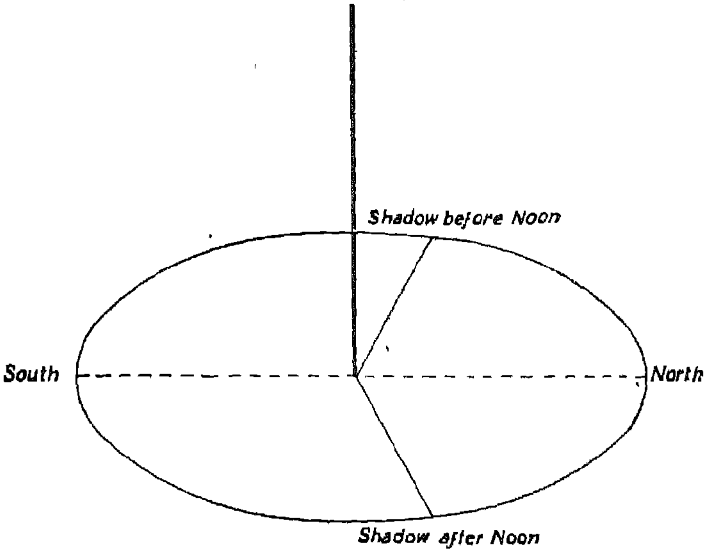

Fig. 15 The Shadow of the Rod and the North

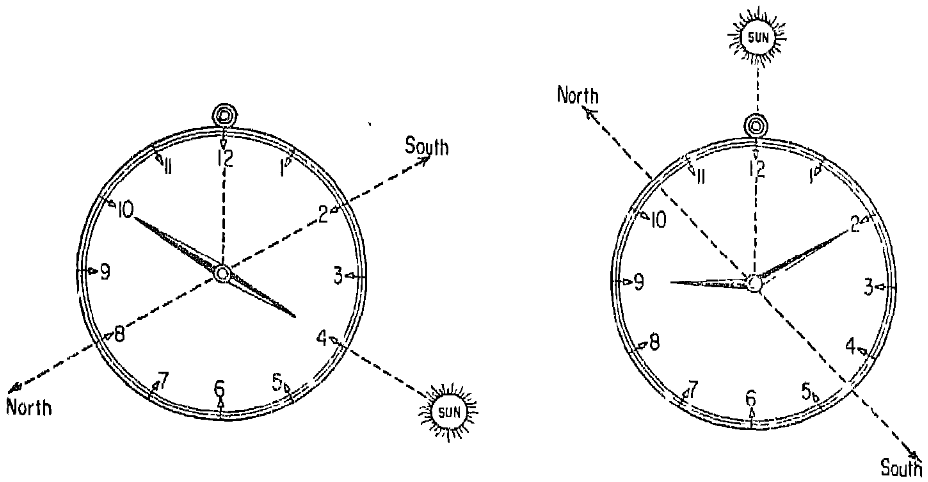

Fig. 16. Directions Determined by Means of the Sun and the Watch

direction is with the help of the magnetic compass. This instrument is not dependent on the Pole Star, the sun, or the clouds. The magnetic compass is the guide for a navigator, a surveyor and an explorer. It is the most useful instrument for fixing directions in surveys (Fig. 17).

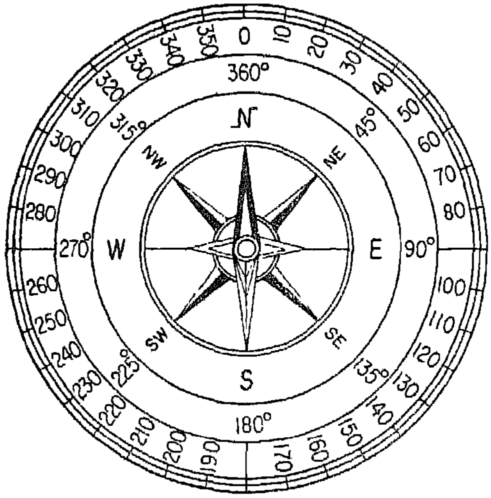

Fig. 17. Dial of the Magnetic Compass

When there are no magnetic substances in the field, the needle of the compass always points to the magnetic north pole which is different from the geographic north pole. Moreover, the magnetic north pole is not a fixed point as it moves slowly from time to time.

The angle between the true north-south line and the magnetic north-south line is known as magnetic declination. It is directly available in books like the Nautical Almanac, but it can be roughly estimated also from the data furnished on topographic maps Since it varies slightly from place to place and from time to time, such estimates are not accurate. Thus, it is easy to find the true north once the magnetic north is found, and the magnetic declination is known.

(*iii*) *Prismatic Compass*—This is a circular magnetic campass. A prism with a slit P is fixed on one side and on the other there is a sighting-vane V with a thin wire running through in the centre. An imaginary plane from the prism to the sighting vane passes through the pivot-pin C in the centre. This makes it easier for reading the bearings of the object sighted.

The prismatic compass is graduated the opposite way to an ordinary magnetic compass

This means that 180° is shown over the north end of the needle and 360° over the south end. A check stop is provided to bring the graduated card to rest while taking the reading. While taking the readings, the compass should be held firmly between the thumb and fingers of the left hand. Usually the compass is fixed on a tripod stand and care is taken to see that while using the compass the prism and the sight-vane are raised and the observations are taken by closing the left eye and looking through the prism-slit with the right eye. The thin wire in the sight-vane is then aligned properly with the object where the bearing is to be recorded. The bearing of an object refers to its direction in relation to the observer. It measures the angle formed by a fixed line through the observer's position and the object observed. A field-book is made for the purposes of recording the observations.

Relevance of Surveying in Geography

Surveying is relevant particularly in field-studies in which large-scale maps and statistical data are not available. Under such situations, the geographer is left with no other alternative but to prepare his own map, however crude. For specific purposes, he may use surveying instruments to be more accurate in his observations and analysis. He can also generate his own data which provides a wealth of information about the geography of the area studied.

EXERCISES

1. Prepare a plan of areas chosen by :
   (a) Chain survey.
   (b) Plane table.
   (c) Prismatic compass.
   Choose three different types of areas such as a school and playground, agricultural area, and a village site.

Chapter 3

CARTOGRAPHIC TECHNIQUES

IN THE previous chapter you have learnt the three important elements of map-making, i.e. scale, projections and surveying. These are the fundamentals of map-making. The next task of the geographer is to utilise the maps for the purposes of studying the distributional patterns of physical, economic and human elements, and their interrelationships This makes the study of geography a live subject. The distributional patterns can be studied at any point of time, i.e using the available data or conducting studies in a particular year. Such studies can also be repeated periodically. In addition, there are methods and techniques for measuring the patterns of changes that are taking place on the surface of the earth. The distributional patterns have two components, structural and spatial, which are complementary to each other in most cases. Let us take up the distribution of different components of an element, say agriculture. The total area under cultivation in a region can be shown diagrammatically in its components such as area under wheat, cotton, sugarcane and so on. Such diagrams are known as statistical diagrams, because the statistical data are represented in the form of diagrams rather than tables. When such diagrams are drawn on a map on the basis of the locations where the particular components are present, the distributional pattern would enable us to understand the variations in the patterns between regions. Let us now study some of the techniques of analysis of the distributional patterns with the help of statistical diagrams and maps.

Statistical Diagrams

The following are the important methods of representation of statistical data in the form of diagrams:

(i) Line-graph
(ii) Histogram
(iii) Pie-diagram
(iv) Bar-diagram
(v) Proportional symbol
(vi) Star-diagram
(vii) Pyramid
(viii) Dispersion diagram.

Line-graphs

Line-graphs, as the name suggests, make use of lines—smooth or curved—to show the absolute value or proportion of agricultural or industrial production, growth of population over a period of time, or data on trade and transport (Fig. 18). A graph paper is used for this purpose in order to locate the points appropriately and to compare two elements in their patterns of distribution.

Example

Prepare a line-graph using the following data on the percentage of urban to total population in India from 1901-1971.

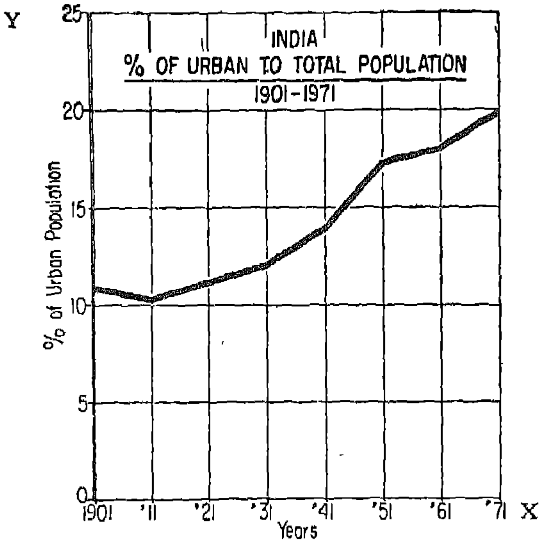

Fig. 18. Line-Graph

Year	*Percentage of urban to total population in India*
1901	10.85
1911	10.29
1921	11.18
1931	12.00
1941	13.86
1951	17.30
1961	17.98
1971	19.87

Procedure

(i) Choose the X-axis for the years and the Y-axis for plotting the percentage of urban population.

(ii) Select appropriate scales for both sets of values e.g. 1 cm = 0.5 for urban population and 2 cm interval for 1901, 1911, 1921, etc.

(iii) Mark the positions for each of the census years on the X-axis and the corresponding figures of urban population on the Y-axis.

(iv) Join the points by a line.

The advantage of showing the values in the form of a line-graph is that it reveals the fluctuations in the pattern of urbanisation as expressed in percentage of population living in urban centres. Line-graphs can be simple (as in the above example) or multiple or compound graphs in which several line-graphs are drawn on the same sheet using common scales.

Histograms

This method of representation involves drawing of rectangles whose heights are proportional to the values to be shown in the form of diagrams. Here, as for the line-graph, graph paper is taken and the X and Y axes are marked to plot the values of the variables. For example, the accompanying illustration is an attempt in showing the frequency distribution of the number of districts, according to certain class intervals of population density per square kilometre. The intervals chosen are equal, such as up to 100, 101-200, 201-300, etc. Often it so happens that the class intervals of a variable may not be the same i.e. it may be a case of unequal class intervals. In such cases, the height of the histogram should be proportional to the ratio of the frequency to the class intervals. Area of each rectangle would then be proportional to the frequency of the corresponding class.

Frequency Polygon and Frequency Curve :

A frequency polygon can be drawn by joining the middle points of the upper sides of the adjacent rectangles of the histograms with straight lines. In Fig 19 the thick line represents the frequency polygon. For an ungrouped frequency distribution, the frequency polygon is obtained by plotting the points on the abscissae (values on X-axis) as the values of the variable and those on the ordinate (values on Y-axis) as the corresponding frequencies, and joining the points by means of a straight line.

If the class intervals are small, the frequency curve can be obtained by drawing a smooth curve through the vertices of the frequency polygon.

The following two examples will make the above procedure clear

Example 1

The district-wise density of population in

Uttar Pradesh is given in the following table for 1971. Represent the data by a histogram.

Population per 1 square kilometre	*Number of districts*
0-100	5
101-200	9
201-300	2
301-400	20
401-500	14
501-600	3
601-700	1

Since the class intervals are equal, the histogram of the above data can be prepared by plotting the class intervals on the X-axis and then drawing a rectangle on each class with a height proportional to the class frequencies measured on the Y-axis. The histogram thus obtained is shown in Fig. 19.

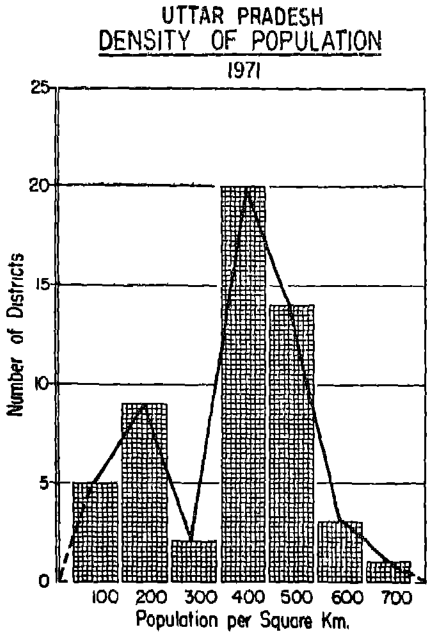

Fig. 19. Histogram

Example 2

The distribution of Indian towns with population less than 100,000 in 1971 is given below.

Population (In thousands)	*Frequency (No. of towns in thousands)*	*Frequency Class interval*
0-5	198	198/5 =39.6
5-10	617	617/5 =123 4
10-20	931	931/10= 93·1
20-50	756	756/30= 25 2
50-100	277	277/50= 5 5

Show the data on a graph by histogram and frequency curve and comment on it

Unlike in example 1, the class intervals in this case are not equal. Therefore, the procedure for the construction of a histogram based on these data will be slightly different. For unequal class intervals we have to divide the frequencies by the class intervals and the heights of the rectangles will be proportional to these ratios given in the third column of the above table. This histogram is shown in Fig. 20.

If we join the middle points of the upper sides of the rectangles of a histogram by a smooth curve, what we get is a frequency curve. The frequency curve of the data is also shown in Fig. 20.

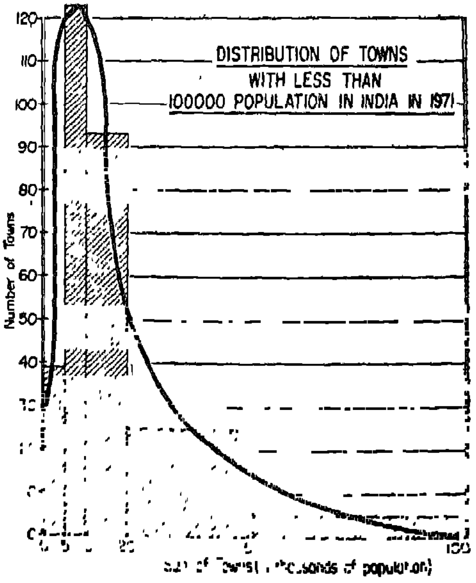

Fig. 20. Polygraph

Comments :

The frequency curve in this case is not symmetrical. This shows that the distribution of towns according to their size classes is uneven. It has more concentration of towns on the smaller side and very few towns on the larger side. The maximum concentration of towns is found to be around 5 to 20 thousand of population.

Pie-diagrams

In this method, circles are drawn with the radius proportional to the values for different observations (Fig. 21). The area of the circle is calculated according to the formula πr^2. Therefore for each of the observation the radius can be calculated in the following manner.

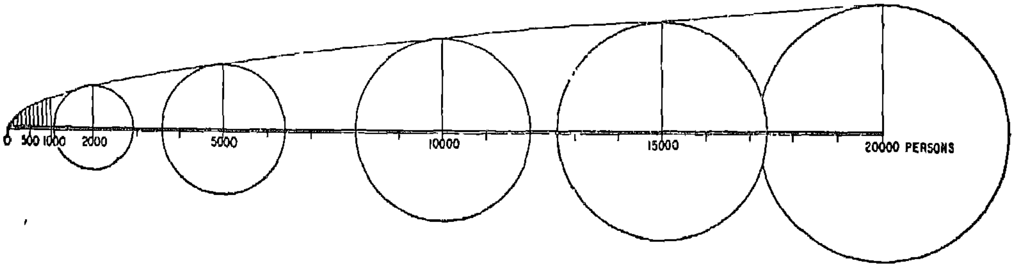

Fig. 21 Graduated Linear Scale for Circles

$$\pi r^2 = 100 \;\therefore\; r = \sqrt{100 \times \frac{7}{22}} = 5.64$$

Observation (X)	$r = \sqrt{X \times \frac{7}{22}}$
100	5.64
200	7.98
500	12.61
800	15.96
900	16.92

The radius of circles for all the intermediate values such as 150, 230, etc. can be determined by preparing a graphical scale which is drawn using the above mentioned values. The utility of proportional circles can be further improved by adding another feature which is related to the first one. For example, we can represent the land use data of different states by a pie-diagram in which each circle is divided into different sectors (which appear as pies) to distinguish different kinds of land uses (Fig. 22). The method of dividing a circle into sectors is as follows.

(i) First draw circles with their radii proportional to the total area of each state.

(ii) Find out the angle for each sector to represent the land uses of different types. These can be calculated by multiplying the percentage of each category of land use by a constant 3.6. This is because 100 per cent represents all the categories of land uses in the form of a circle where angle at the centre is 360°.

Bar-diagrams

Consider the table below showing the population of 9 States in 1971. Unlike the frequency distribution table, this one has only one numerical variable, i.e. the population given in column 2. Column 1 has only names of the

States	*Population (In lakhs)*
Uttar Pradesh	737
Bihar	465
Maharashtra	396
Andhra Pradesh	360
West Bengal	349
Tamil Nadu	337
Karnataka	324
Gujarat	236
Rajasthan	206

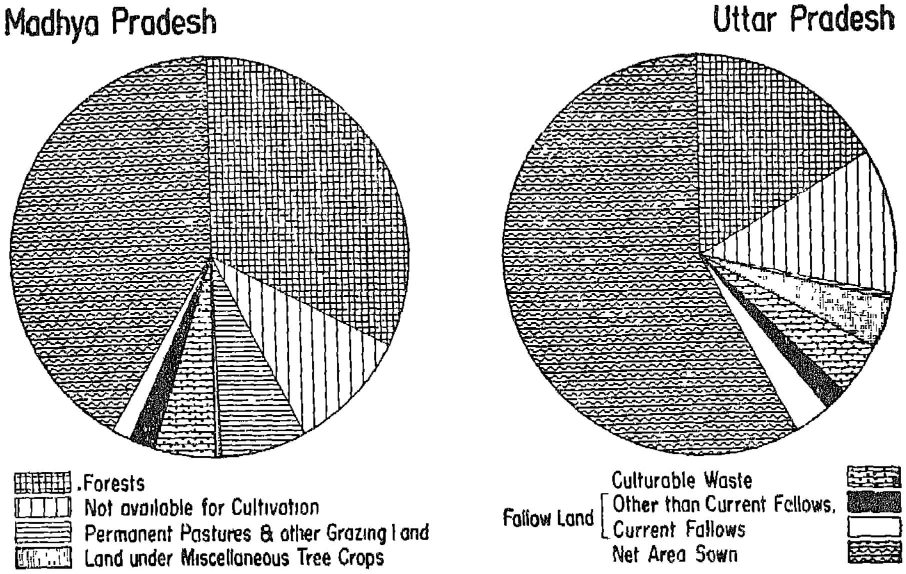

Fig. 22 Pie-Diagram Showing Land Use

states which are not the quantitative variables in the sense that any State can be placed anywhere in the column.

The figures given in the above table can be represented by a bar-diagram. It is obtained by drawing equally spaced bars of equal width. Heights of the bars will be proportional to the values of each observation (i.e. population in the present case). The bar-diagrams based on the above mentioned data are shown in Fig. 23.

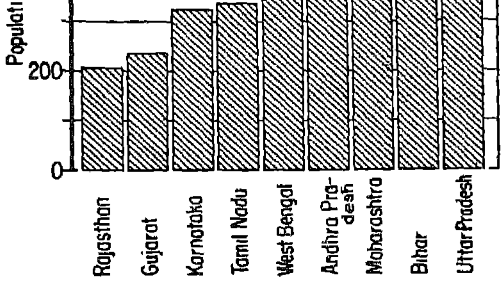

Fig. 23. Bar-Diagram (Vertical)

Other examples using bar-diagrams are the production of different crops or of different industries, and other characteristics of the economy.

Multiple Bar-diagram :

The method of bar-diagram sometimes can be extended for showing two or more sets of data in one diagram. These sets are often such that their comparative positions give more insight to the problem under study. For example, the literacy among the people of India shows large variations in rural and urban areas. It also varies considerably among males and females. Any bar-diagram showing the literacy can thus be represented by two sets of literacy data, i.e. literacy of the rural population and literacy of the urban population. The following data showing the rural and urban literacy of India in five states can be plotted by a multiple bar-diagram as given in Fig. 24.

State	*Percentage of literates in rural and urban areas*	
	Rural	*Urban*
Assam	25.80	58 68
Madhya Pradesh	16.81	49.55
Kerala	59.28	66.31
Jammu and Kashmir	14.11	38 17
Maharashtra	30.63	58.07
India	23.74	52.44

Proportional Symbols

Squares and cubes :

This is a method of representation in which like rectangles we can use two dimensional figures such as cubes. The squares or cubes are piled up one above the other and they can be counted easily. In the case of a square, the area is proportional to the quantity represented, while, in the case of the cube the volume is proportional to the quantity represented.

Example

Production of rice in India and the share of some States to the total production in 1971-72 are to be diagramatically shown.

The data shown above are represented in the form of squares in Fig. 25.

Other symbols ·

Use of symbols is one of the simplest me-

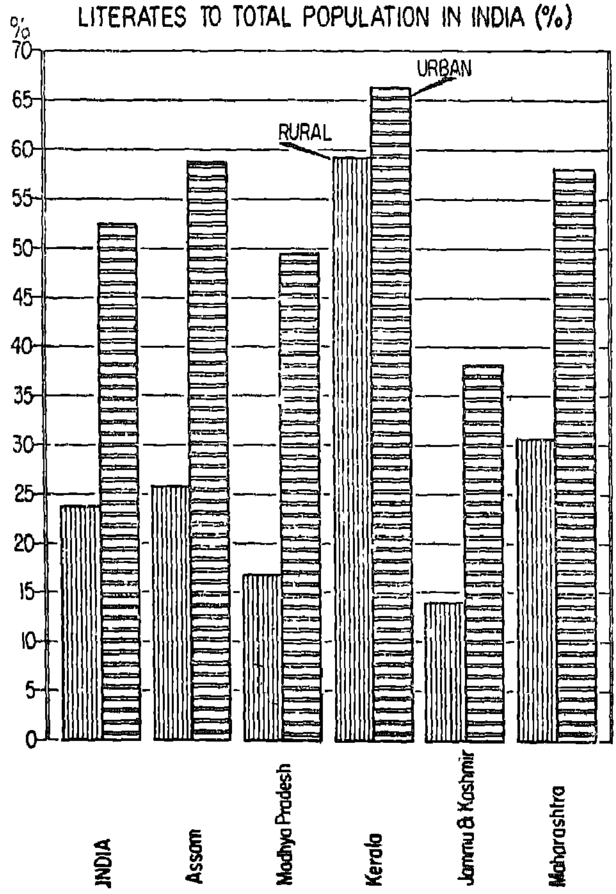

Fig. 24. Multiple Bar-Diagram

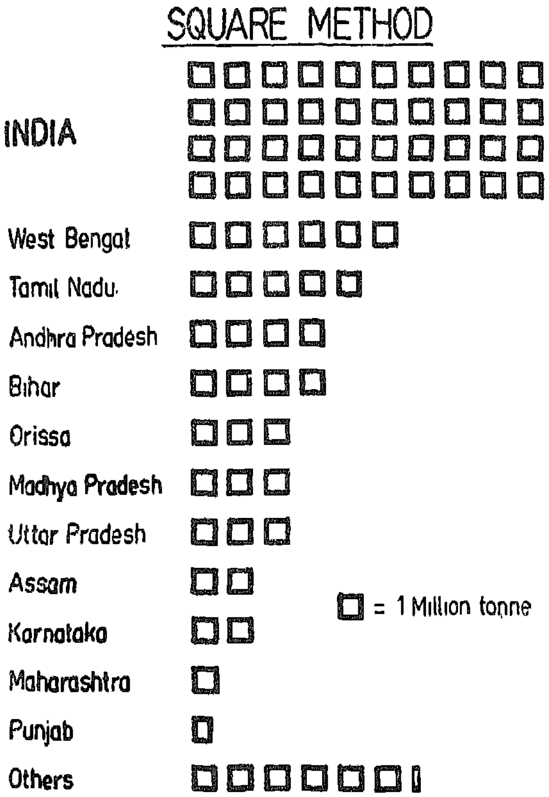

Fig. 25. Square Method—Rice Production

	Production (In million Tonnes)
India	40.0
West Bengal	6.0
Tamil Nadu	5.0
Andhra Pradesh	4.0
Bihar	4 0
Orissa	3.0
Madhya Pradesh	3 0
Uttar Pradesh	3.0
Assam	2.0
Karnataka	2.0
Maharashtra	1.0
Kerala	1.0
Punjab	0.8
Others	5.2

thods by which the distribution of one or more features can be shown on the same map. For example, given the data on industries by their types, e.g. steel mill, cement plant, sugar mill, wood processing industry, etc., we can show them by a variety of symbols or by differential shading of the same symbol as in Fig. 26. If an industry has several establishments in the same place, the symbols representing this industry are arranged vertically, one above the other, and the same procedure can be followed as in showing several industries by types.

Graded symbols are also used in some cases. Suppose, the populations of rural settlements are to be shown on a map. One method would be to classify rural settlements by population sizes, say, five classes with a symbol for each or six sizes of graded circles for cities and towns of different size categories like census classes 1 to 6, instead of a continuously graded series as discussed earlier in this chapter (Fig. 26 A and B).

Star-diagrams

As the name suggests these diagrams appear like stars with rays radiating from their centres. The lines drawn from the centres in all directions will be proportional to the quantity represented. The ends of such lines are then joined to give the appearance of a star. This technique is most suited in the preparation of diagrams and maps based on climatic data. A wind-rose is a common example of this type of a diagram, which will show the direction of the wind on different days or months of the year. Likewise, the lines radiating from the centre could represent 12 months of the year and the length of the line would represent the amount of rainfall. When these diagrams are located on a map on the basis of meteorological stations they bring out the regional and seasonal variations in rainfall effectively (Fig. 27).

Pyramids

The diagram appears like a pyramid and

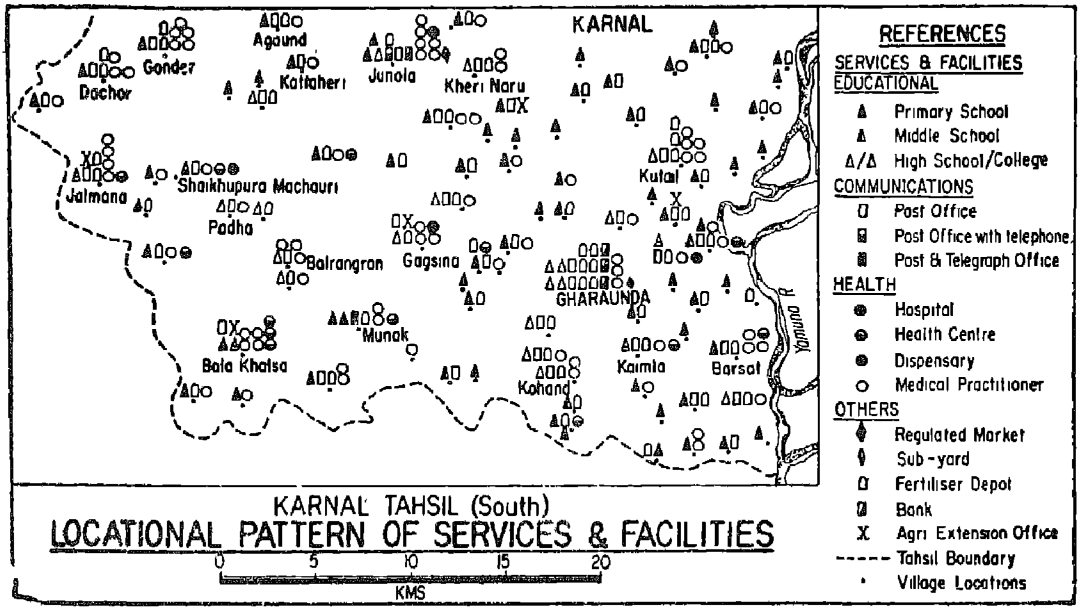

Fig. 26 A Symbols—Locational Pattern of Services and Facilities

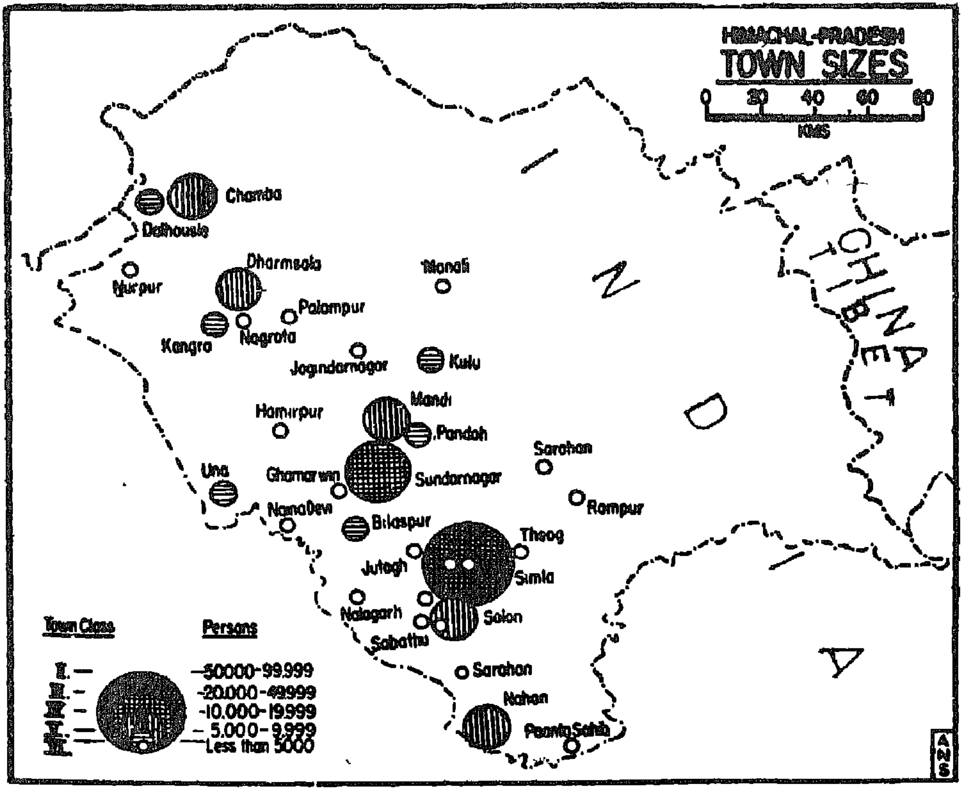

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Fig. 26 B. Graded Circles—Town Size

hence the name. This method of representation is most suitable for showing the demographic structure of population—distinguishing the male and female population by different age-groups such as less than five years, 5-15 years, 15-30 years, 30-55 years and above 55 years of age.

The columnar diagrams constructed to represent the absolute values or percentages of any type of data discussed earlier in this chapter, can be arranged horizontally in the form of a pyramid (Fig. 28). In the case of demographic data in which male and female populations by age groups are to be shown separately, the columns or bars representing these populations are drawn on either side of a vertical line choosing appropriate scale for population in each age group. The columns are so arranged that the youngest age group is shown by the columns at the base and the oldest at the top. The shape of the pyramid would vary according to the demographic structure of population of different countries or of regions within a country. We may use States as regions of India or any other type of region for which the demographic structure has to be presented in the form of a population pyramid. You will notice that the columns on either side of the vertical line may show distortions according to the variations in the number of people (male and female) in different age groups (Fig. 28).

Dispersion Diagrams

Often, we are required to study the variations in the distribution of some geographical elements over a period of time, as in the case of the distribution of rainfall month-wise and its fluctuations over the years. We would like to know whether the distribution has been uniform or subject to variations. The measurment involves the comparison of the observed values around a central value, and the upper and lower quartile values (Refer to Chapter 6 for details). Such a diagram which helps us to measure the variations around the central value is known as the dispersion diagram (Fig. 29).

Techniques of Mapping

The various ways of representing statistical data in the form of diagrams described in the foregoing pages were meant to give you an idea of the methods of representation and analysis of the data which are of interest in geographical studies. These diagrams can also be suitably transferred on to maps. It would depend upon the nature of the data. Such statistical diagrams often help us to understand the patterns and variations better than the data presented in tabular form. Often, statistical tables and diagrams are complementary. There are, however, certain geographical elements which need to be mapped in order to understand the distributional patterns over the surface of the earth. For example, variations in landforms can be better analysed with the help of a contour map than a large number of locations at which the heights above the mean sea level are plotted. In the same way, the area-wise distribution of rainfall, crops, population, etc. can be better analysed by mapping the data using appropriate cartographic techniques. We shall illustrate some techniques of preparing maps using statistical data. As you will see for yourself some techniques are common to several types of data that can be presented as maps. For instance, contour or isopleth maps can be used for relief, rainfall, population density or crop yields.

Dot Maps

This is perhaps the simplest method of showing the distributional pattern of population, crops, etc. using absolute figures without having to work out the percentages or ratios (Fig 30). The method, as the name suggests, utilises dots for the purpose of showing the distribution. The size and scale of the dots would depend upon the scale of the map and the nature of the data. Dots when used effec-

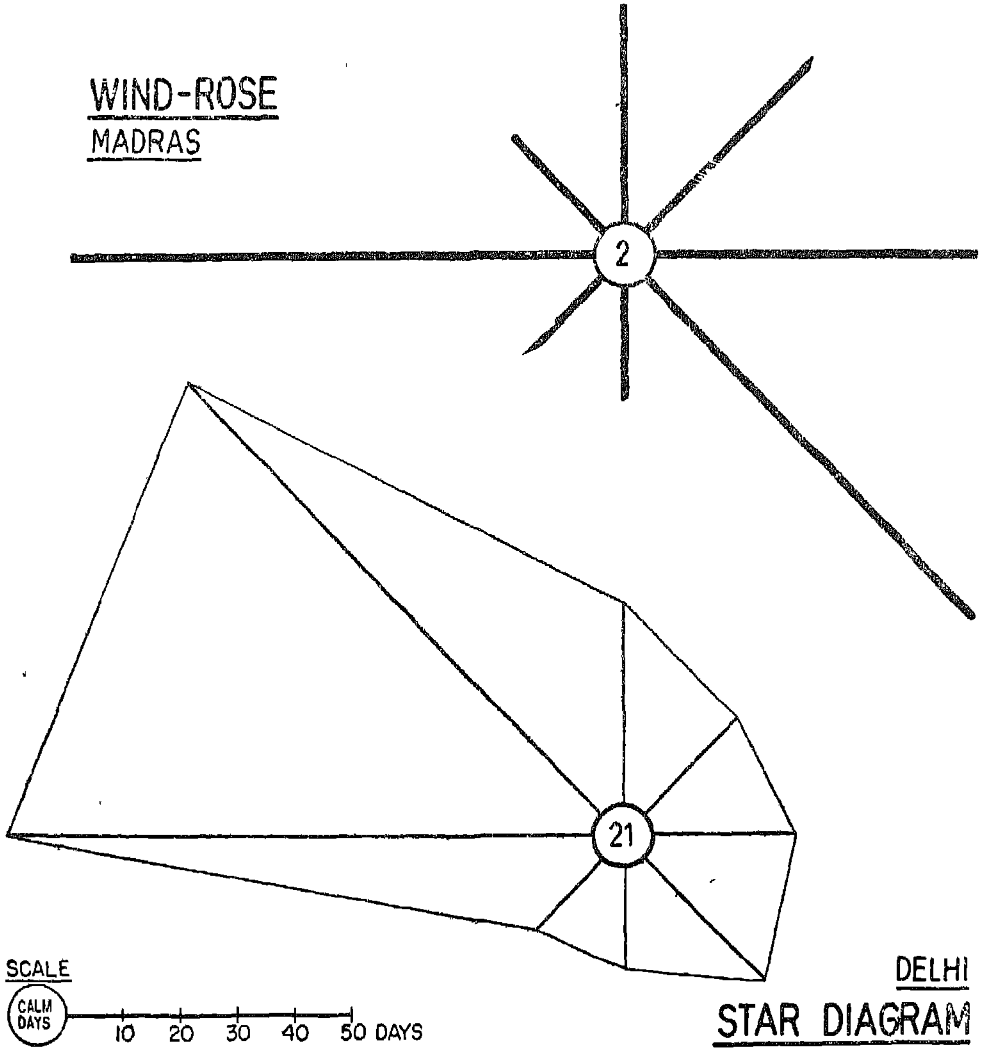

Fig. 27. Wind Rose and Star Diagram

tively and to the accuracy permitted by the scale of the map will reveal the distributional pattern as close to the actual ditribution on the ground as possible. This is specially true when the scale of the map is large, e.g. in showing the distribution of cultivated area in a tract comprising groups of villages or for a tahsil or small district. In such cases, geographical factors which influence the distributional pattern may be taken into account. For example, in a rugged area with alternating valleys and hill ranges the relatively flat cultivable lands can be marked off on the map by tracing the limits of cultivation or appropriate contours from a topographical map of the area. A suitable scale is chosen for the dots, say, one dot=10 acres, if it is cultivated area or one dot=10 persons if it is of population. Fractions of the dots will not be plotted. The dot method is also useful for certain purposes, where. small-scale maps

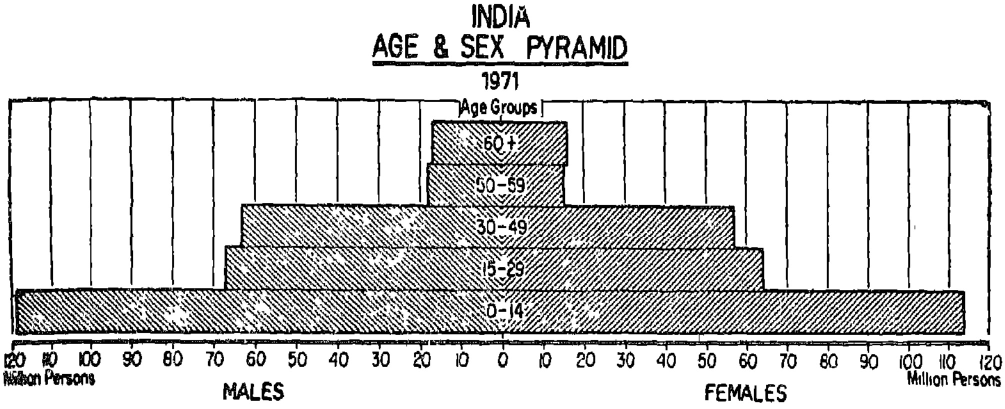

Fig. 28. Age-sex Pyramid—India's Population (1971)

could be informative, but it has a serious limitation in that the dot may not be near the place where the feature to be mapped actually exists. However, in showing the distribution of crops like jute and coffee which are concentrated in few areas, the dot method would serve the same purpose as a choropleth map of the same crop.

The dot map, whether on a small-scale or on a large-scale, could become more informative by choosing two or more colours for the dots to represent different elements as in the case of rural and urban population or crop acreages under different crops,

Isopleth Maps

Isolines are imaginary lines connecting all the places with similar values. So, they resemble contours in relief mapping and we sometimes use isopleths, isolines and contours as interchangeable terms. The technique of draw-

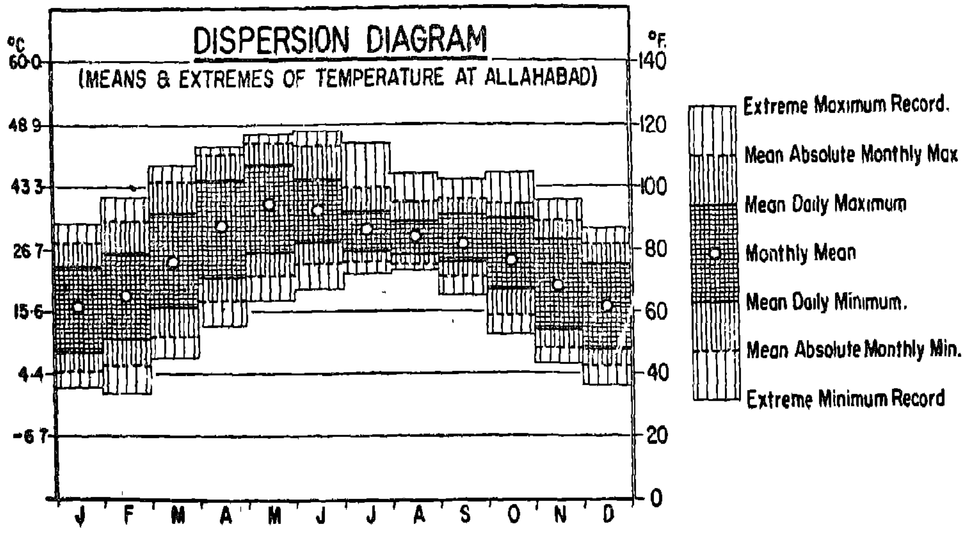

Fig. 29. Dispersion Diagram

ing isopleth maps (Fig. 31) is essentially based on this principle. If the data to be mapped are based on administrative units, the value for each such unit is plotted at the centre of the district, tahsil or village, as the case may be, and the selection of suitable class intervals is made on the basis of the study of the frequency distribution of all the observations. Smooth lines are then drawn through points with identical values or are interpolated proportionately between the values plotted on the map.

In the accompanying map, the rainfall data of all the meteorological stations are used in drawing the isopleth map of rainfall distribution. The class intervals are chosen (*see* Chapter 6) as low, medium, high, etc. Line-shading is then employed to bring out the variations in the amount of rainfall clearly. Dark shades may represent higher values. Colours can also be used to bring out the same effect. Similar techniques are employed in mapping the following features :

(i) Land forms.

(ii) Population density.

(iii) Distribution of crops.

It should be noted that in many cases the absolute numbers are first converted into ratios, percentages or into an index of concentration before plotting the data on a map. For example, while drawing a map of population density per square kilometre in India, the population of each district is first divided by the total area of that district. Likewise, the area under each crop is expressed in terms of the percentage to total cropped area.

The advantage of the isopleth technique is that the distributional patterns and variations are realistically represented by the method of interpolation. The pattern of isolines helps us in differentiating the areal patterns of change from one class interval to the other, whether the change is abrupt or gentle.

Choropleth Maps

In this method, the boundaries of the particular administrative units for which the data are compiled are first drawn on a map (Fig. 32). The ratios or percentages of population or crops are plotted in pencil inside each administrative unit. Alternatively, the values of ratios or percentages are first arranged in descending order and suitable class intervals of values are chosen by studying the frequency distribution of the values (*see* Chapter 7). The class intervals are then marked A,B,C,D, etc. The values for each administrative unit are then examined in relation to these categories and the corresponding letters are marked inside each administrative unit. Appropriate line shadings or colours are used to bring out the patterns and variations. Groups of administrative units with similar value ranges would then appear to form one homogeneous group. The boundaries of administrative units having similar values can be retained if identification of individual administrative units is important.

There are advantages as well as limitations in the use of choropleth techniques. By retaining the administrative boundaries it becomes possible for the aggregation of the data on a regional basis with groups of administrative units forming homogeneous regions in terms of similarity in the values. The interpretation of the patterns becomes easier to administrators and planners. The limitations arise mainly because the administrative units are often of different shapes and sizes and the patterns of distribution shown on the basis of these units may not reflect the realities of distribution patterns on the ground, because a large district may sometimes have two very different parts within its boundaries.

Flow Maps

The term 'flow map' conveys the idea of movement and hence these are 'dynamic' maps (Fig 33). They are drawn by using data on the movement of people and commodities. Two features of such maps are important: (i) the direction, and (ii) the number of people or the quantity of the commodities moved. For the

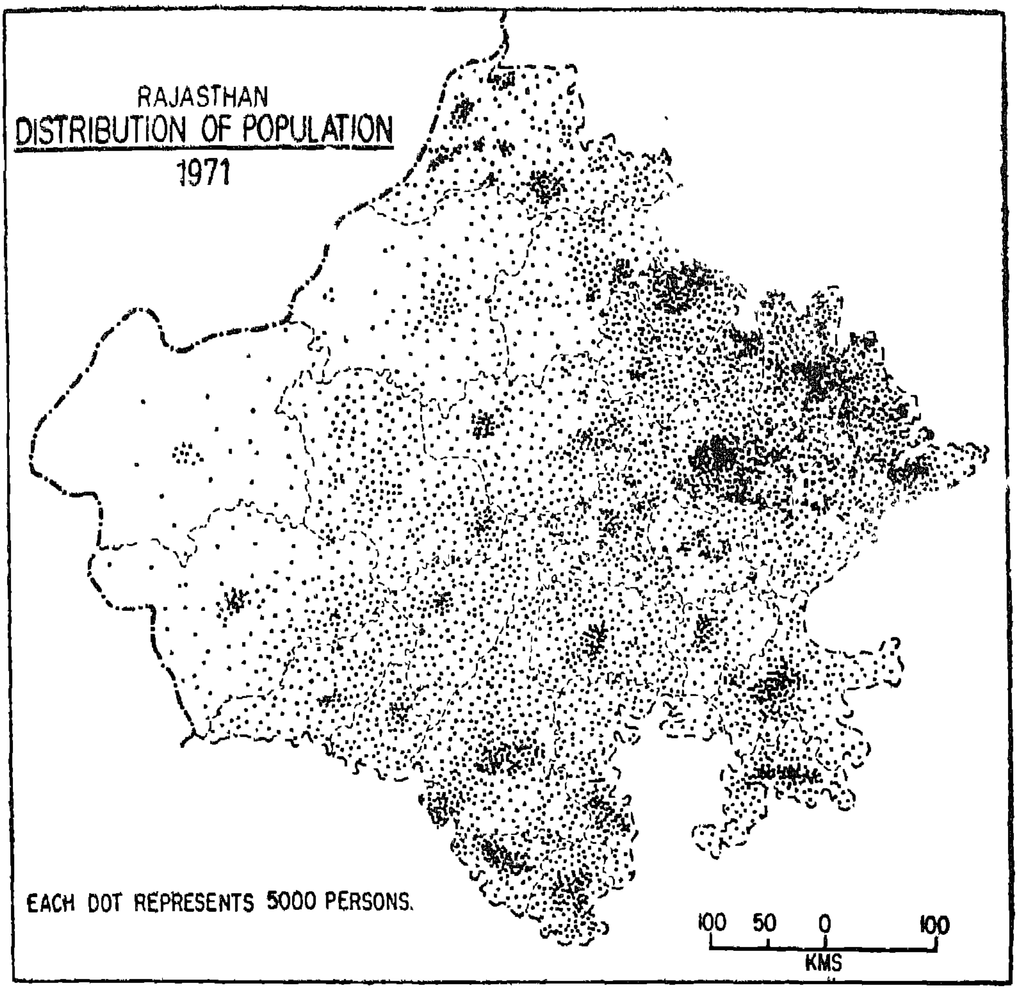

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Fig. 30. Dot Method—Distribution of Population

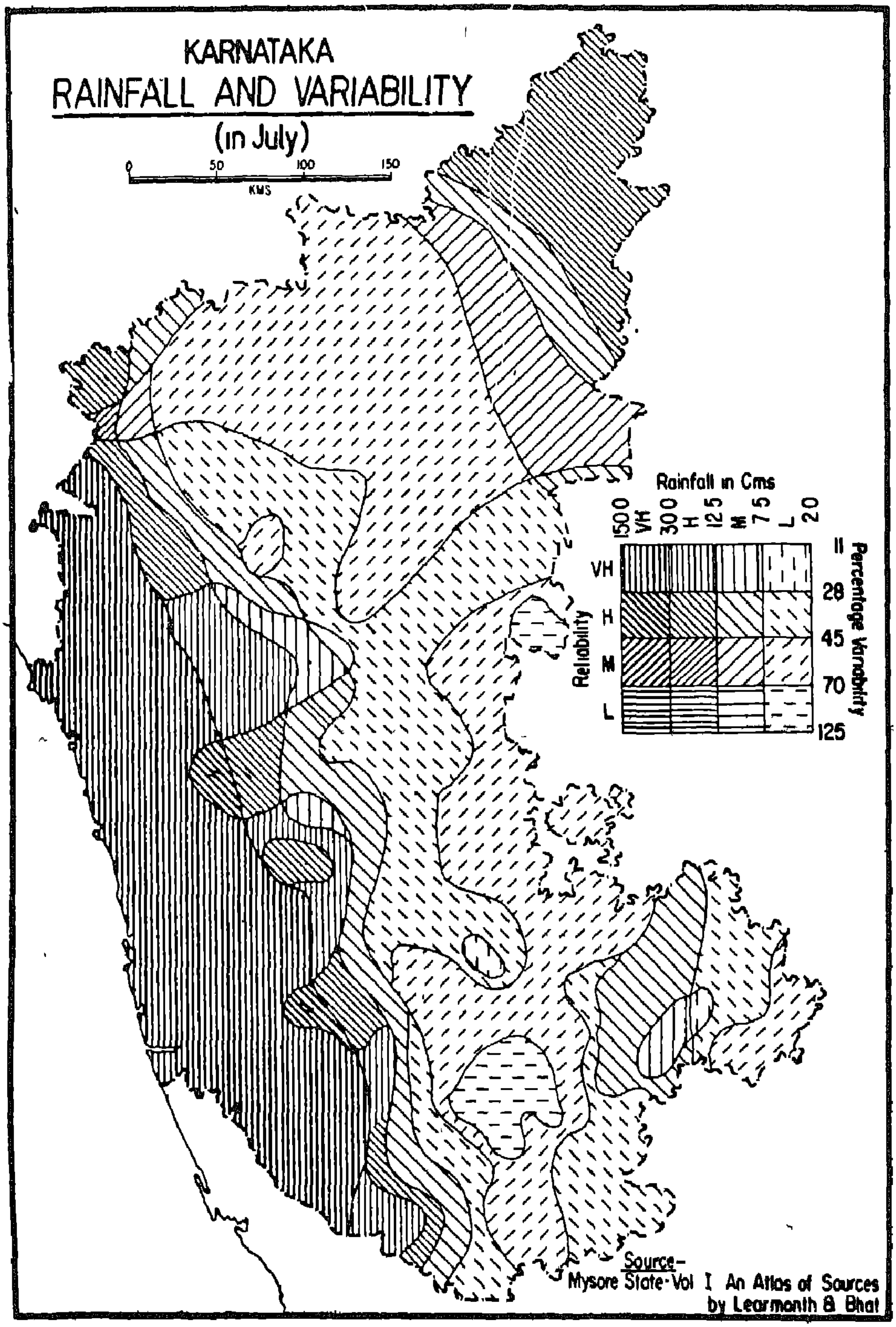
construction of these maps the following procedure is adopted.

(i) A map of the selected area is drawn, showing important places and the transport routes such as roads and railways

(ii) Data on the movement of people or commodities from the place of origin to its destination are compiled.

(iii) A suitable scale is chosen to represent the number of people or the quantity of the commodity by a thickness of line (or ribands) proportional to the number of persons or the quantity of goods.

The ribands of appropriate thickness are drawn on either side of the transport route to show the movement in each direction. Different line-shading or colouring for two ribands would serve to bring out the variations in thickness of the ribands clearly. Likewise, at places where the flow ribands converge, the

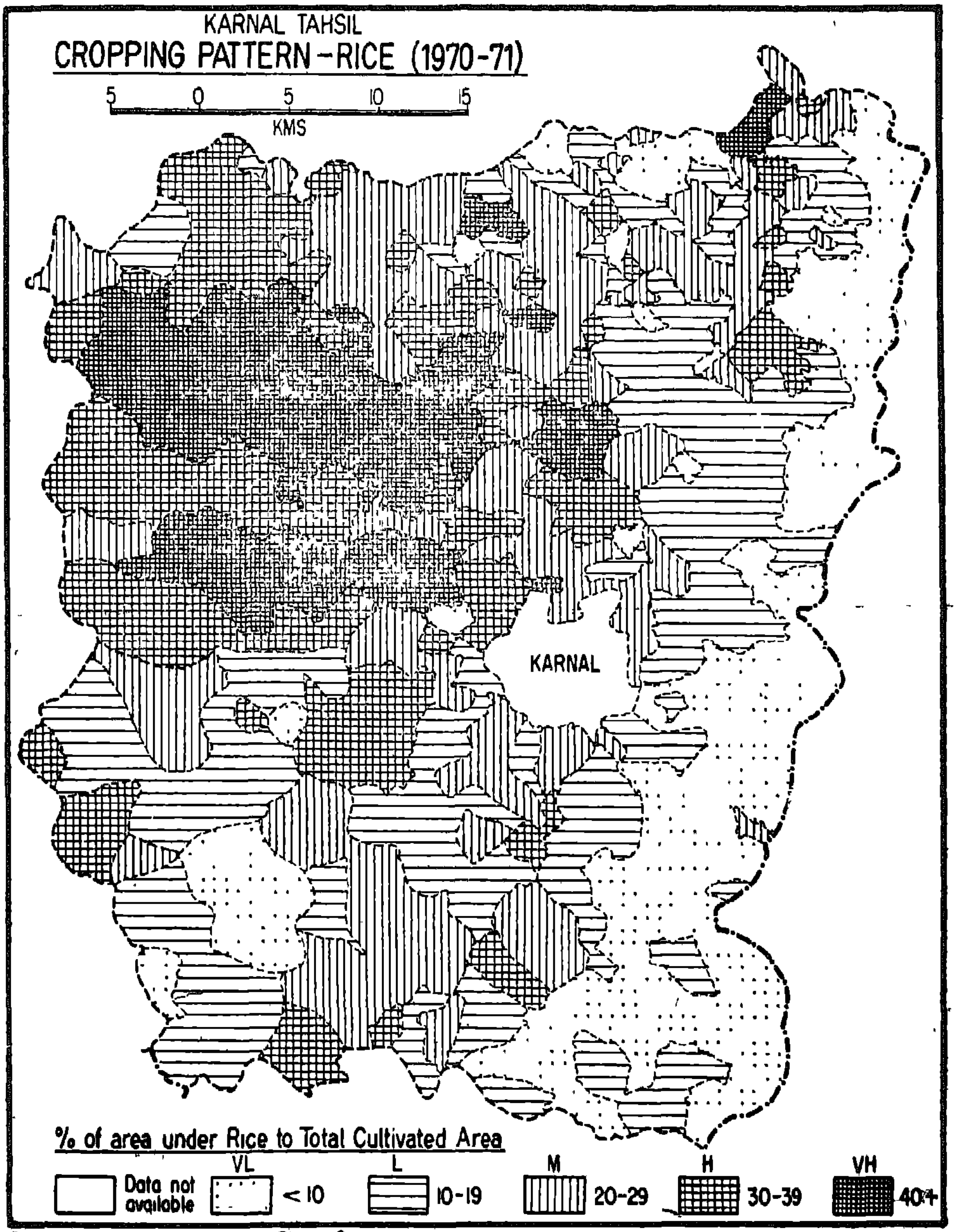


Source–
Mysore State-Vol I An Atlas of Sources
by Learmonth & Bhat

Fig. 31. Isopleth Map—Distribution of Rainfall and Variability

thickness of ribands and its variations would serve to distinguish the places according to their levels of importance. These places of convergence of commodities and people are called nodes.

From Fig. 33 you may notice that Karnal is an important node while the intensity of movement is high along the road linking Karnal and



Source: Micro-level Planning by Bhat L S

Fig. 32. Choropleth Map—Cropping Pattern

Panipat with Delhi further south. Another use for the flow map is in the delineation of the spheres of influence of places which appear on the flow map as nodes This is done by closely examining the thickness of the flow ribands from the nodes outwards. The abrupt change in the thickness is marked off on the map in all directions. Often, the thickness would increase after some distance as one approaches another important place to which people and commodities move. This would serve to divide the study area into a number of nodal centres

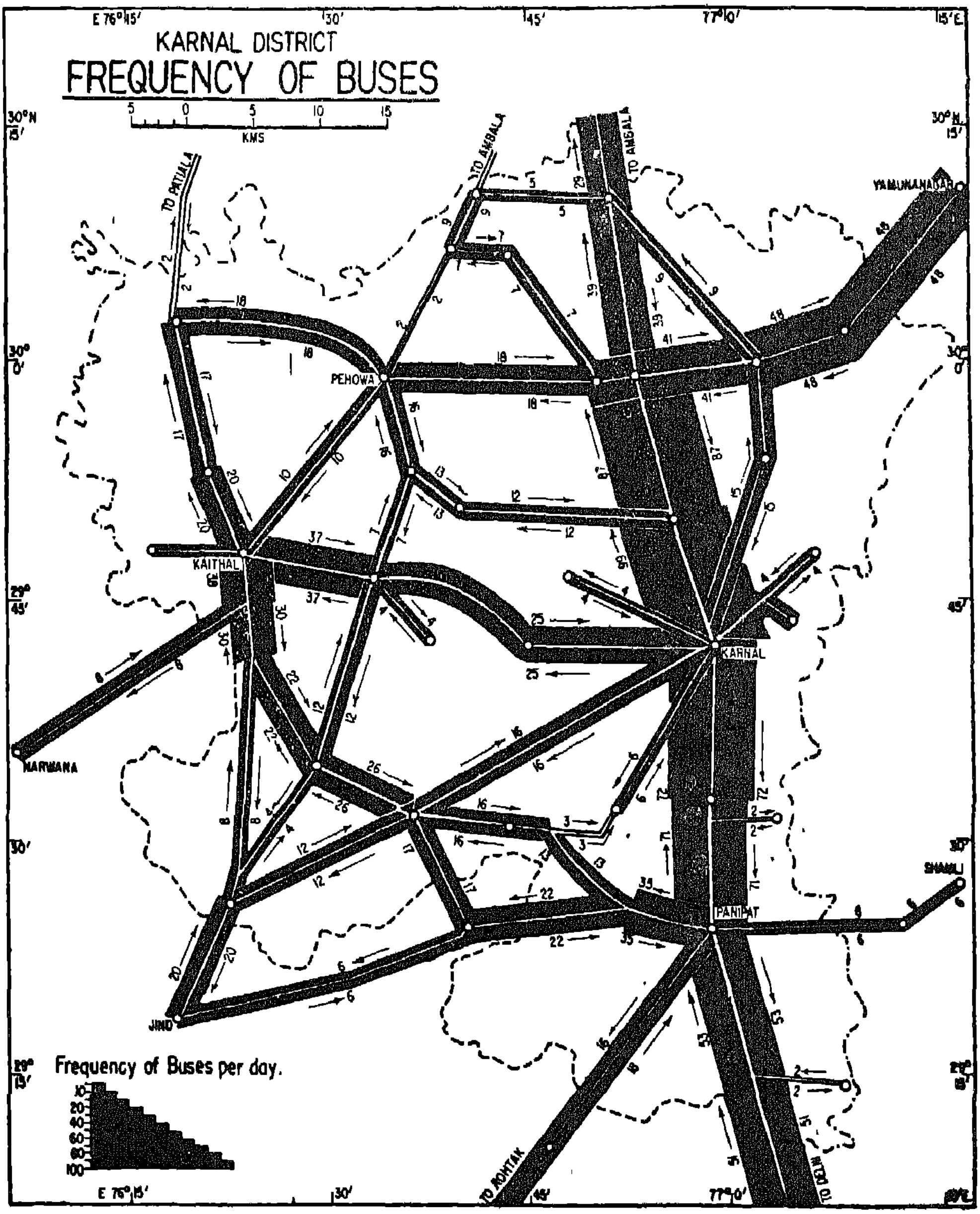


Fig. 33. Flow Map—Frequency of Buses

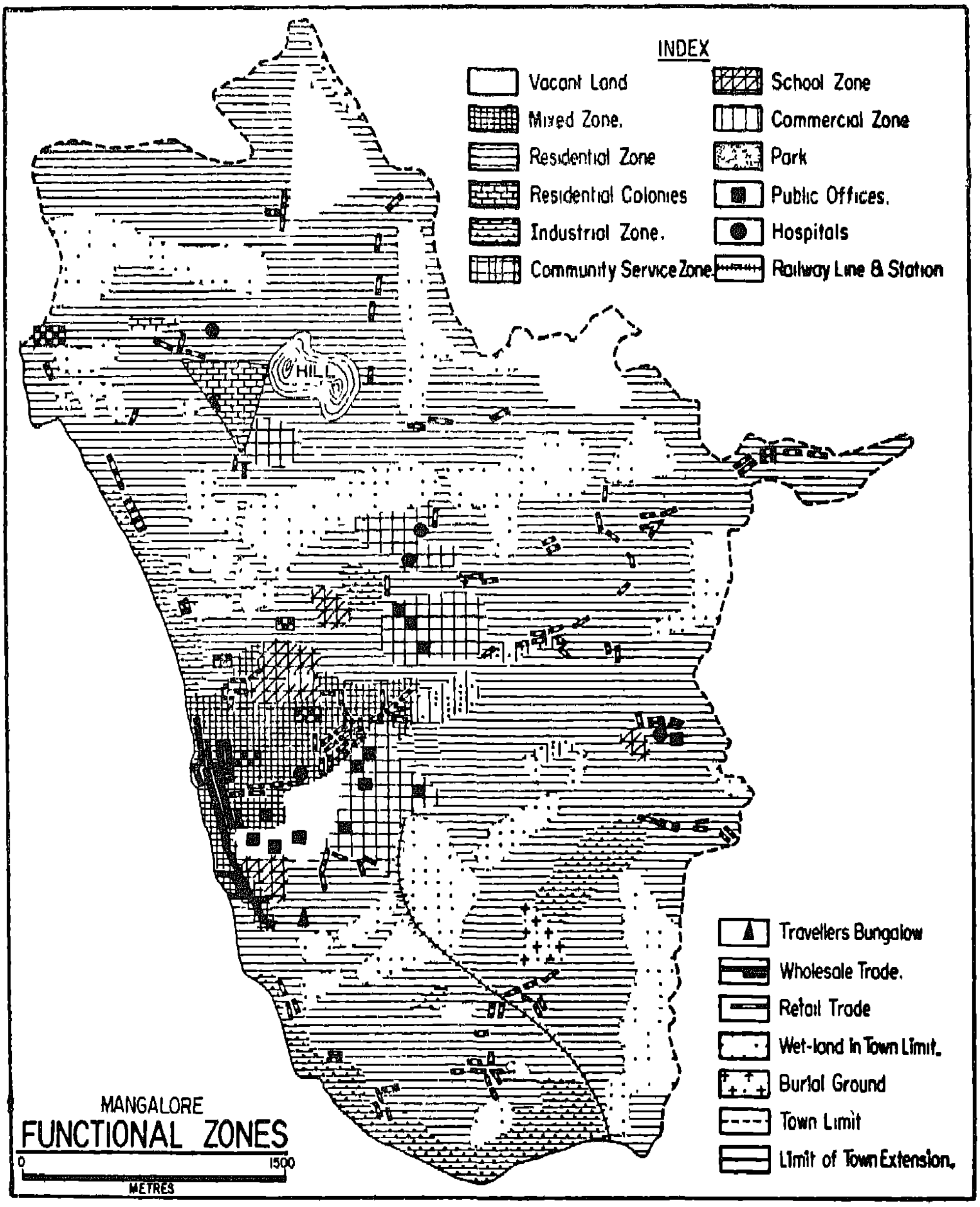


Fig. 34. Chorochromatic Map—Land Uses
(Source : Towns of Mysore State by Rao, V.L.S.P.)

and their spheres of influence (nodal regions).

In the case of commodity flow maps, the flow ribands can be further sub-divided according to the type of commodity and the quantity moved. These aspects have also been described in Chapter 6 under the section on Field Work.

Unlike the data on land use, population, etc., the data on the movement of people and commodities are difficult to obtain. The study of

flow patterns constitutes a specialised theme in geography. Because of the lack of data on the actual movement of people and commodities, you may have to make use of the frequency of buses and railways based on the guides to bus routes and railway time tables.

Chorochromatic Maps

Chorochromatic maps can be drawn specially where the distributional patterns and forms of settlements are to be shown on a map (Fig. 34). These are often highly generalised as in the case of a map of a city or a village wherein different areas have to be shown according to varied land uses or settlements, e.g. commercial and residential areas, parks and playgrounds industrial areas, schools, hospitals, etc. In the case of a rural settlement, the houses can be differentiated according to different communities or occupations. It is a qualitative map in which symbols and line shadings or colours are employed simultaneously. Another application of the chorochromatic technique is in showing the pattern of expansion of the towns and cities during different periods of time.

Graded Symbol Maps

The techniques of representation of statistical data in the form of diagrams have been discussed in the earlier pages. Where the data are on the basis of locations of places or areas, those diagrams are also drawn on the maps to bring out the distributional patterns and variations. These would include maps of regional variations in the distributional patterns of industries, facilities for education, health, banking, communications and recreations.

Chapter 4

MAP INTERPRETATION

THE MAP is the most important tool of a geographer in the analysis and interpretation of various features distributed on the surface of the earth. Maps could be informative, analytical or prescriptive (as in the case of maps for planning). Thus, maps can serve a variety of purposes. Many of you would have seen tourist maps of various hill stations, historical and religious places, large cities and new towns around large industrial establishments. They are of limited use unlike the topographical maps which provide us a wealth of information on the physical features, natural vegetation, distribution of villages and towns, roads and railways and some of the facilities that are available such as rest house, market, post-office, temples, mosques and churches. This is why maps are defined as models of "real world" situations. Of course, no map can perfectly depict reality because of several reasons. The time factor is important because every feature on the surface of the earth is subject to change. There is also the problem of scale of the map. Some loss of information is unavoidable if the maps are of small scale, as you have learnt in the section on scales.

Classification by Scale

Maps can be classified in different ways. One of the classifications is according to the scale, viz. (i) cadastral, (ii) topographic, and (iii) atlas and wall maps.

Cadastral Maps

Basically, cadastral maps pertain to cadastre, i.e. a public register of the lands of a country for the purpose of defining property in legal documents and levying taxes. In practice, however, they include maps drawn on a fairly large scale to show accurately the extent and measurements of every field and plot of land. For example, maps drawn in the scale 1 : 2,500 or 25 inch maps, i.e. where 25 inches on the map represent one mile on the ground, are cadastral maps. These are useful in preparing land use maps of a village or town.

Topographic Maps

Topographic maps are intermediate between a general map or a small scale map on the one hand and a plan or a cadastral map on the other. They are based on the actual survey of the land and their scale is large enough to show roads, plans of towns, contour-lines and other details. But they do not show boundaries of individual fields and plots. They usually depict the detailed surface features as forests, rivers, lakes, and man-made features such as roads, railways, canals and settlements.

Common scales of topographic maps, or topo-sheets as they are generally called, are 1 : 50,000, 1 : 62,500, 1 : 63,360 or 1 : 100,000. In India, the Survey of India prepares topographic maps for all parts of the country on different scales.

Atlas and Wall Maps

If cadastral or large scale maps stand at one end of the scale, atlas and wall maps stand at the other. Atlas maps are small-scale maps. They represent a fairly large area at a glance and present a bird's eye view of a region and as such do not depict all the details which a topo-sheet does.

Even so, an atlas map serves as a graphic encyclopaedia of geographical information about different parts of the world to those who know its language and understand how to consult it. When consulted properly, it lends a wealth of generalised information regarding location, relief, vegetation, climate and distribution of population. Systematic use of an atlas gives an insight into the major economic activities and political events discussed in daily newspapers.

Wall maps are maps intended to convey the main features of a small or large area in a bold manner. They are drawn on a larger sheet and as such are useful for a large group of students in a classroom as they can be hung on the wall and can be read from a distance.

Classification by Function

The second classification of maps relates to their functions. For example, maps may show relief, climate, vegetation, population, means of transport, land use patterns, and political divisions.

Relief Maps

Relief maps give us an idea of surface features or landforms such as plains, valleys, plateaus, ridges and mountains. They also provide information regarding the drainage of the region. With a little practice, it becomes possible to interpret such maps and visualise the landscape and its features.

These maps are helpful in finding out suitable sites for human settlements, construction of roads, dams and canals. To a certain degree they provide a clue to the agricultural potential of the region, depending upon how plain or hilly is the terrain and its water resources.

Climatic Maps

Climatic maps provide us with information regarding temperature, pressure, rainfall, wind and conditions of the sky. They supply genera lised information based on data collected over a period of time. These maps give us an idea of climatic conditions in different parts of the world.

These maps are useful in determining natural vegetation and agricultural produce. They also throw light on how favourable or otherwise is a particular region for human habitation.

Population Maps

Population maps help us to understand the distribution of population, both rural and urban, and also the growth of population over a period of time. A large number of maps have to be prepared to understand the important aspects of man-environment relationship. These would include demographic, occupational, socio-cultural and economic aspects of development in different parts of the country. For preparing these maps, we need a variety of statistical data and we have to use appropriate techniques of showing them on a map.

Political-Administrative Maps

Apart from the maps mentioned above, it is necessary for the geographer to consult maps showing the political and administrative units. These maps are important for the purpose of preparing base maps in using statistical data which are generally compiled on the basis of these units. For example, in India, the following are the hierarchical levels of political administrative units and these are shown on maps prepared by the Survey of India and the Central and State governments: the Nation as a whole, State and Union Territories, Districts, Tahsils (talukas) or Thanas, and Villages. According to the purpose and the type of data to be mapped, we can prepare a base map of a proper scale for mapping the statistical data.

Reading of topographic maps or topo-sheets involves the "setting" of the maps and understanding their conventional language comprising signs, symbols and scales used in depicting the various physical and cultural features.

Setting of the Map

When one reads a local topo-sheet in the field, it is necessary that it must be set properly, i e. the north point on the map should correspond to the true north. We usually use a magnetic compass to find out the north. But it must be remembered that the north shown by the magnetic compass is not the true north or the geographic north but the magnetic north. Once we find out the magnetic north we can easily locate the true north fairly accurately, since the magnetic declination or the degree of variation of the true north from the magnetic north is indicated on every topo-sheet. In practice it is easy to set or 'orient' a topo-sheet by identifying the main features it contains with their locations in the field.

Use of Conventional Signs

Setting of the map and understanding its scale are the important preliminaries of map-reading. It is equally important for the map-reader to make himself familiar with the symbols used on the map. These are provided in each topo-sheet in an abridged form. Further, the Survey of India issues a large sized table showing these symbols. The purpose of using such symbols on a map is to make it both informative and legible as far as possible. The common symbols, including the letterings and symbols used for representing various relief, vegetation and cultural features, are known as conventional signs (Fig. 35).

A reader who is familiar with the conventional signs used by the Survey of India on its topo-sheets can read almost any map of any country, even if the language is foreign, without much difficulty , since most of these symbols are of universal applicability.

Use of Standard Colours

Apart from conventional signs and symbols, topographical maps depict the distributional pattern of different land uses by standard colours. These are also internationally accepted techniques of depicting land uses. The important land use features and the colours used are as given below.

Land use	*Colour*
Cultivated area	Yellow
Forests	Dark Green
Grass land	Light Green
Uncultivable land	Brown
Built-up areas i e. village site, towns, roads etc	Red
Water features	Blue

Given a topographical map (coloured) you should be able to trace out different types of land uses on tracing paper and study their extent and pattern of distribution. You will notice that there are sharp contrasts in colours and their pattern of distribution in different maps depending upon the geographical characteristics of the area represened on a map. You have to analyse the causes for such variations based on a study of the land forms, drainage, climate and other characteristics of the region.

Interpretation of Physical Features

The surface of the earth is a mosaic of mountains, valleys, plains and seas. These elevations and depressions of the earth's surface are known as reliefs of the earth. Reliefs are best represented by models which are three dimensional, but they are expensive and cumbersome to handle Moreover, their vertical scale is often considerably exaggerated as compared to the horizontal scale.

A relief map depicts the elevation of the land above sea level on a flat surface. Various methods are employed to show such relief on maps. These are : contours, form-lines, layer-colouring, hill-shading, and hachures. Sometimes a

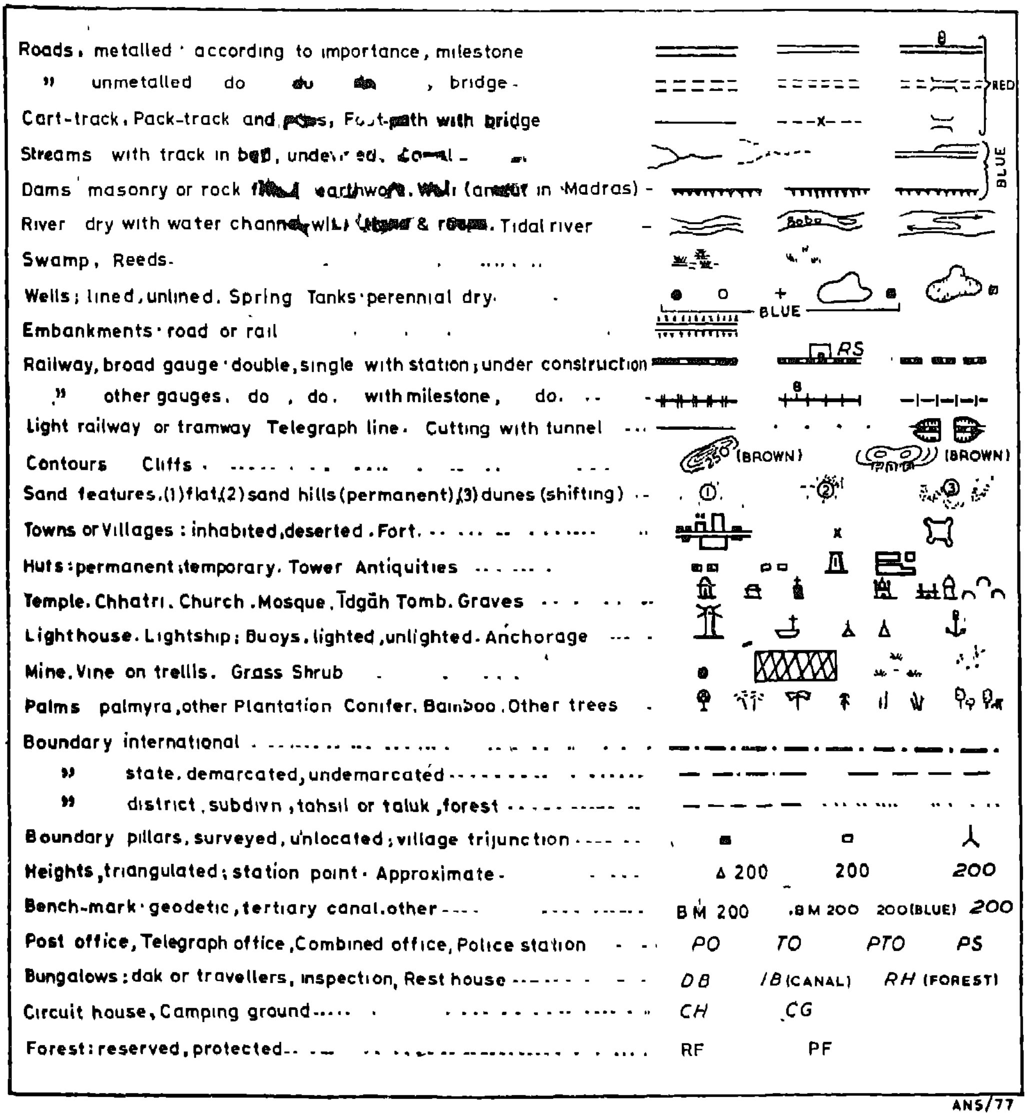

Roads, metalled according to importance, milestone
" unmetalled do do do, bridge
Cart-track, Pack-track and pass, Foot-path with bridge
Streams with track in bed, undefined, Canal
Dams masonry or rock filled earthwork, Weir (anicut in Madras)
River dry with water channel, with island & rocks. Tidal river
Swamp, Reeds
Wells; lined, unlined. Spring Tanks perennial dry
Embankments road or rail
Railway, broad gauge double, single with station; under construction
" other gauges, do, do, with milestone, do.
Light railway or tramway Telegraph line. Cutting with tunnel
Contours Cliffs
Sand features, (1) flat, (2) sand hills (permanent), (3) dunes (shifting)
Towns or Villages: inhabited, deserted. Fort
Huts: permanent, temporary. Tower Antiquities
Temple. Chhatri. Church. Mosque. Idgāh Tomb. Graves
Lighthouse. Lightship; Buoys. lighted, unlighted. Anchorage
Mine. Vine on trellis. Grass Shrub
Palms palmyra, other Plantation Conifer. Bamboo. Other trees
Boundary international
" state, demarcated, undemarcated
" district, subdivn, tahsil or taluk, forest
Boundary pillars, surveyed, unlocated; village trijunction
Heights, triangulated; station point. Approximate
Bench-mark geodetic, tertiary canal, other
Post office, Telegraph office, Combined office, Police station
Bungalows: dak or travellers, inspection, Rest house
Circuit house, Camping ground
Forest: reserved, protected
RED
BLUE
BLUE
RS
B
(BROWN)
(BROWN)
x
△ 200
200
200
B M 200
.B M 200
200 (BLUE)
200
PO
TO
PTO
PS
DB
IB (CANAL)
RH (FOREST)
CH
CG
RF
PF
ANS/77

Fig. 35. Conventional Signs

combination of these methods is adopted, e.g. contours and hachures, or contours and hill-shading.

Contour

A contour is an imaginary line (drawn on the map) joining points having the same elevation above the mean sea level. In other words, a contour is a line of constant elevation or equal altitude above sea level. A map showing configuration of a surface by contours is called a contour map (Fig. 36). The method of showing relief through contours is perhaps the most precise, useful, common and popular. This method is very useful for presenting relief features with great precision. It is particularly

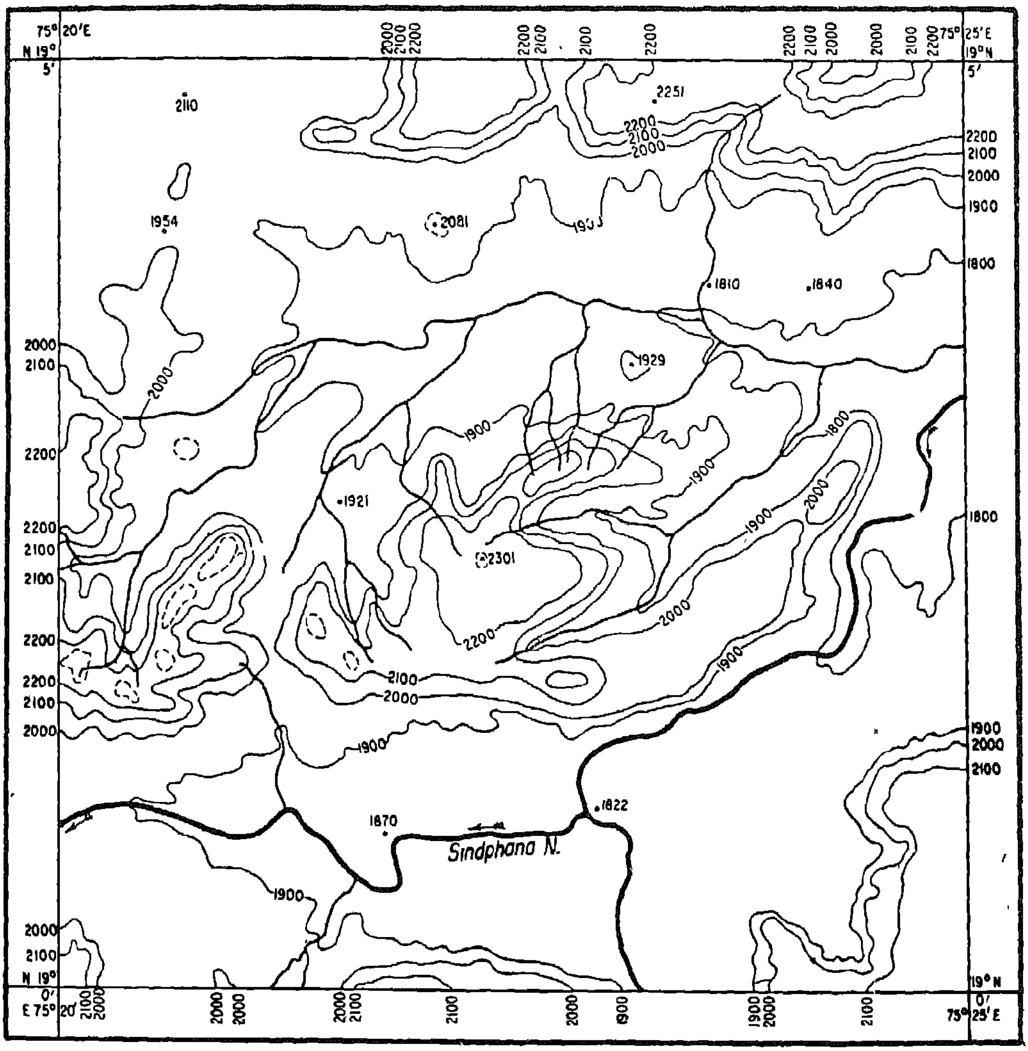


Fig. 36. Contour Map

useful if the region is small and has to be studied carefully in all its details.

Until recently contours sometimes called contour-lines, used to be drawn on the basis of actual survey conducted in the field. But now more sophisticated, quick and precise methods like aerial photo-surveying ~~and computerised~~ mapping, have made contour-making much easier, and much larger areas can be covered.

Contours are drawn at different intervals, say 20, 50 or 100 metres, or 50, 100 or 200 feet, above mean sea level. The interval between two successive contours is usually called the vertical interval (V.I.). It is usually constant on a given map and its unit is metre or foot. While the vertical interval between two contours remains constant, the horizontal distance between the two varies from place to place depending upon the nature of the slope. This horizontal distance is known as the horizontal equivalent (H.E.). It is generally given in metres or yards. The H.E. is greater for gentler slopes and lesser for steeper ones.

Sometimes, broken lines running in the direction of contours are used in addition to contour lines to represent hilly or mountainous country. These are called form-lines. They are not as accurate as contours, and are approximations based on observations by surveyors without direct measurements. They help to indicate minor details which cannot be easily shown by contour lines especially when the contour interval is large, as is usually the case with maps representing mountainous topography.

Layer Colouring

Layer colouring is a very common method of showing relief or elevation. The sea is coloured blue. Usually deep blue indicates deep sea and light blue stands for shallow waters. Lowlying areas are shown in deep green and, as the land rises in elevation, light green, light brown, dark brown, crimson, red and white are used in the same order

A key is provided to explain the limits of height represented by each colour. The method is useful in giving a generalised picture of the relief of a large region.

Hill-Shading

In the hill-shading method, the relief of the region is shown on the map by shading only those slopes which face south and east. In other words, it is assumed that the region concerned is illuminated by a lamp from the north-west, and the region facing the south and east will be in shade. Very often, this method is used in association with contours (Fig. 37 a & b).

Hachures

Hachures are lines drawn on a map to give an idea about the differences in the slope of the ground. They are lines drawn along the direction of maximum slope. Hachures are drawn from the highest point of a hill or a ridge to its bottom and are perpendicular to contour lines. They are made thick and put close together when the slope is steep and thinner and farther apart when the slope is gentle (Fig. 38). On such a map the darker and crowded hachures represent steep escarpments, and thinner and lighter ones gentler slopes. The blanks show

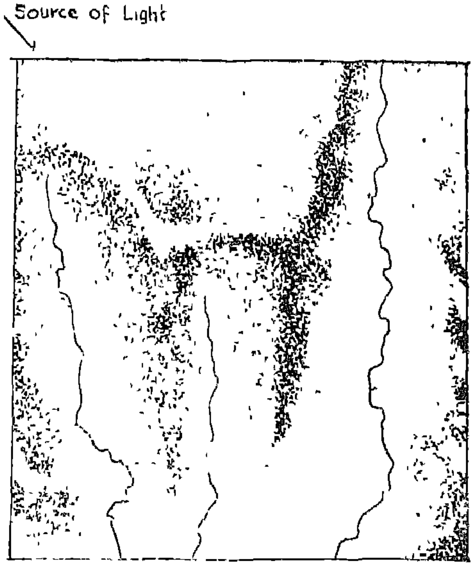
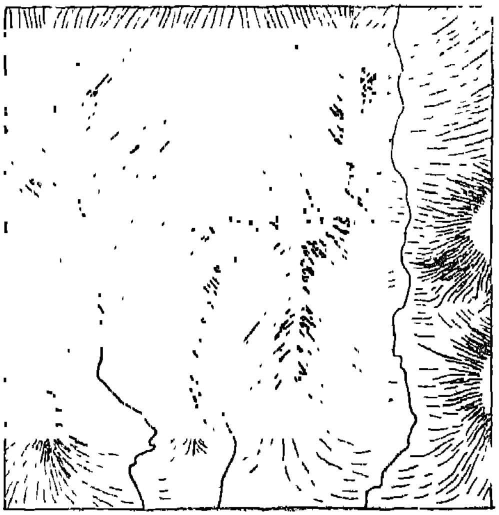


Fig. 37. (a) Relief by Hill Shading



(b) Relief by Hachures

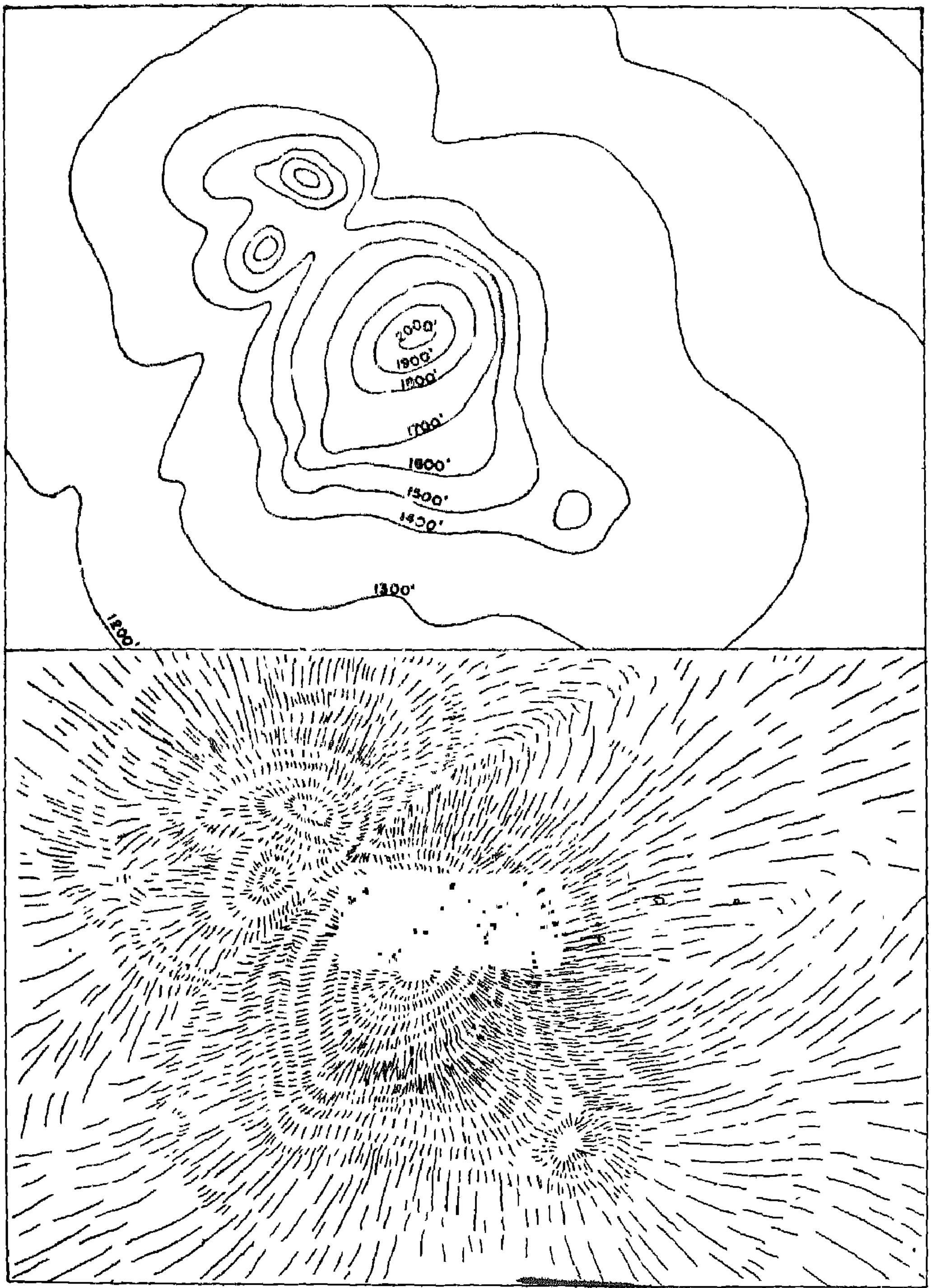


Fig. 38. Relief by Contours and Hachures

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plateaus, table lands, hill tops and flat valley bottoms. Hachures give a fairly good idea of the configuration of land, but do not indicate actual heights.

Interpolation of Contours

Before one knows how contours are drawn on a map, one has to understand "spot heights" and "bench marks". Surveyors find out the exa ctheight of the ground surface above sea level at a few spots with the help of their surveying instruments. The heights, thus found out in the field and plotted at the corresponding points on the map, are known as spot heights. The spot height is shown on a map by a dot followed by a number giving the height in metres or feet.

Often the heights of specific points on prominent and durable material objects like rocks or buildings in the field are recorded for the sake of permanent reference. These heights are determined instrumentally with great accuracy and recorded up to one decimal point in metres or feet. These are known as bench marks. On the map, a bench mark is indicated by B.M., followed by the number giving the actual elevation of the mark and not that of the ground. They are very useful for field workers since they readily serve as points of reference for determining the heights of other places. Bench marks thus add to the utility of a map.

Interpolation of contours becomes possible once the spot heights of a few places in the field are plotted at their corresponding points on the map. First of all, one has to study carefully the highest and the lowest spot heights plotted on the map and to find out the range of elevation. This leads to the next step of determining the contour interval which has to be uniform and suitable for the purpose. Usually it is expressed in round figures, such as 20, 50 or 100 metres, depending upon the total range of elevation (Fig. 39).

In this figure since the range of elevation is 520 metres, it may be convenient to choose the contour interval of 100 metres which is a round figure. Now start with the lowest contour-line which in this case is 1,200 metres. The contour-line will have to pass through a belt bounded by 1,100 metres on one side and 1,300 metres on the other. The exact courses of the contour-line will be determined by the spot heights ranging between 1,100 metres and 1,300 metres, assuming that the slope from one spot height to the other is uniform. Therefore the contour of 1,200 metres while passing between two respective spot heights of 1,150 metres and 1,250 metres will be just midway between the two points. Again, while passing through 1,130 metres and 1,210 metres it is clear that it will be closer to the latter. To be exact, the distance between these two spot heights is to be divided into eight equal parts and the contour is drawn seven units away from the 1,130 metres spot height and only one unit away from the 1,210 metres mark. Now you can draw for yourselves the contours from the rest of the spot heights.

While drawing contours on a map, a few points must be kept in mind. Contours neither start nor end abruptly in a given area. On a map, they either run from margin to margin or from closed patterns. Contours of the different values cannot cross each other. However, for waterfalls and cliffs, where the drop is almost

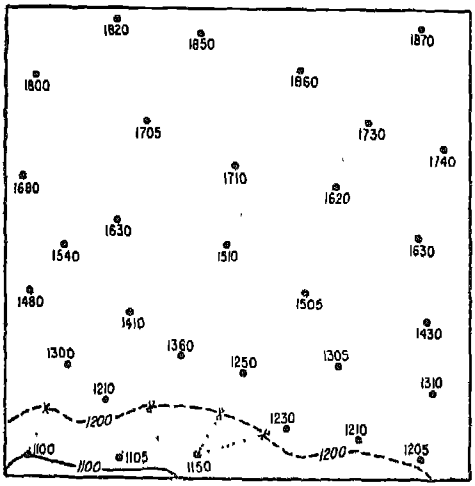

Fig. 39 Interpolation of Contour

perpendicular to the ground, they may merge to form a single contour. In such cases, a special cliff symbol is commonly used Care must be taken to give the contour value on the line itself, or on that side on the line that is towards the rising ground Its value must also be given at the points where it cuts the margin of the map.

Representation of Relief

The spacing of contours is significant to us since it indicates the gradient. The contours are close when the slope is steep and they are farther apart when the slope is gentle. The closed patterns developed by contours give us an idea about the shape or form of various physical features on the earth's surface. It is interesting to know how some of the physical features are represented by typical contour patterns.

A Conical Hill—It rises almost uniformly from the surrounding land. A volcanic cone is a typical example of such a hill. A conical hill with uniform slope is represented by concentric contours spaced almost regularly (Fig. 40)

A Plateau—A flat-topped high land rising above the adjoining plain is called a plateau In the representation of a plateau the contrast between the closely spaced contours of the marginal slopes and their absence or wide spacing on the plateau surface is well marked (Fig. 41).

A Ridge—This is a high elongated hill or a chain of hills forming a long narrow strip of high land very often with sharp edges. It is represented on a map by contours of more or less elliptical shape (Fig 42).

A Plain with a Knoll—It is low, detached hill and is usually round. Very often, plains contain such knolls here and there. Small enclosed contours, usually circular in shape, represent knolls, whereas well spaced contours, or their absence over the rest of the region, indicates a plain (Fig. 43).

A Valley—It is a low lying area of land between two hills or ridges often occupied by a river. It is generally represented by V-shaped contours. The contours recede from the low land and press back into the hills or the higher land. Thus the apex of the 'V' points to the

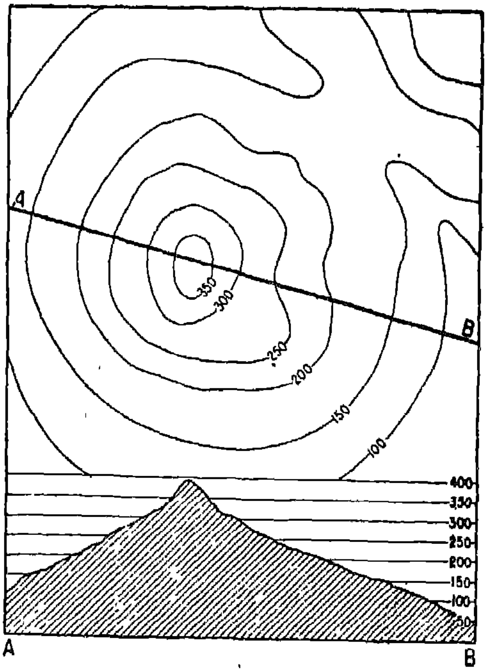

Fig. 40. A Conical Hill

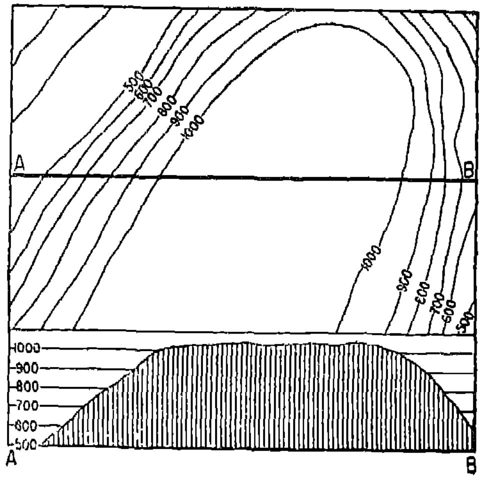

Fig. 41. A Plateau

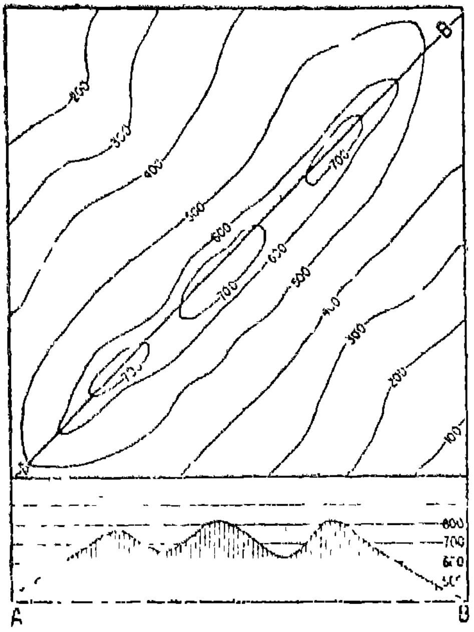

Fig. 42. A Ridge

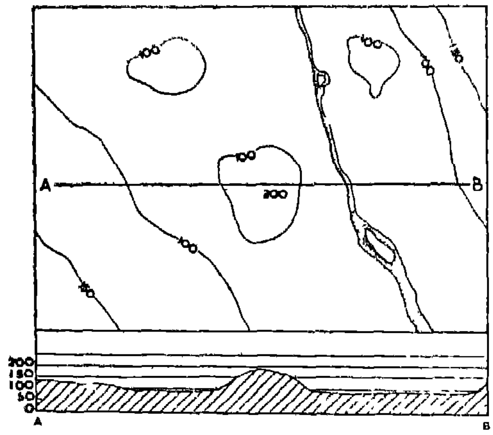

Fig. 43 A Plain with a Knoll

higher ground and its arms to the lower (Fig.44).

A Spur—A tongue of land, projecting from higher ground into the lower, is called a spur. It is also represented by V-shaped contours but in the reverse manner. The arms of the 'V' point to higher grounds and the apex of 'V' to lower ones (Fig. 44).

A Cliff—This is a very steep or almost perpendicular face of land form. It has considerable height and overlooks a lake, a river, a sea or a plain On a map, a cliff may be identified by the way the contours run very close to one another ultimately merging into one (Fig. 45). Sometimes, a special symbol is used.

A Waterfall—A sudden and more or less perpendicular descent of water from a considerable height in the bed of a river is called a waterfall. On a map, it can be identified when contours merge into one while crossing a river stream (Fig.46).

Types of Slopes

Evenly spaced contours indicate a uniform slope. When the contours are closer at the foot of a hill as compared to those at the top, the slope is said to be convex. The knowledge of these contour formations is important from the point of view of visibility. In the case of the convex slope of a hill, persons A and B standing at the top and the bottom respectively will not be able to see each other. This is due to the intervening ground that intercepts their sight. When the contours at the top of a hill are close as compared to those at the bottom, the slope is said to be concave. In such a case, persons standing at positions A and B will be able to see each other as no ground intercepts their line of sight (Fig. 47).

Drawing of a Cross-section

A contoured map gives us a fairly good idea about the nature of the terrain. In order to visualise the nature of the landscape depicted on the map it may be useful to draw cross-sections along a few lines.

If a portion of the ground is cut vertically along a certain straight line, the side view of the cut forms a cross-section. It is also called a section or a profile. A railway-cutting is a kind of profile.

A cross-section thus not only gives us an exact idea of heights, slopes and depressions

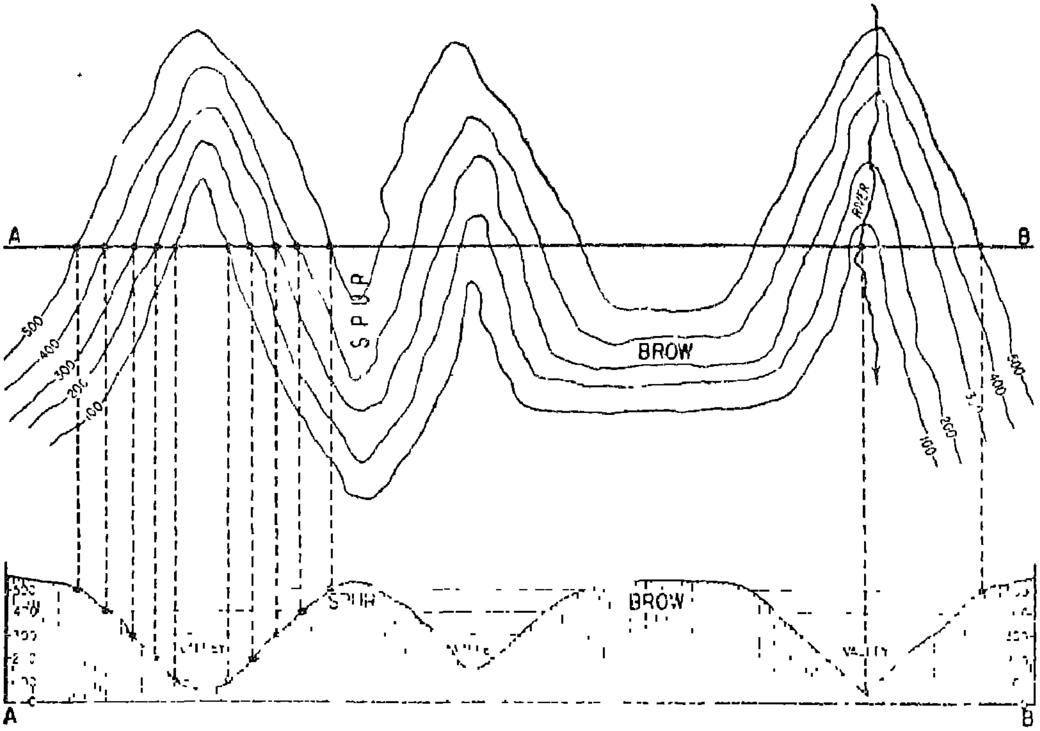

Fig. 44. A Valley and a Spur

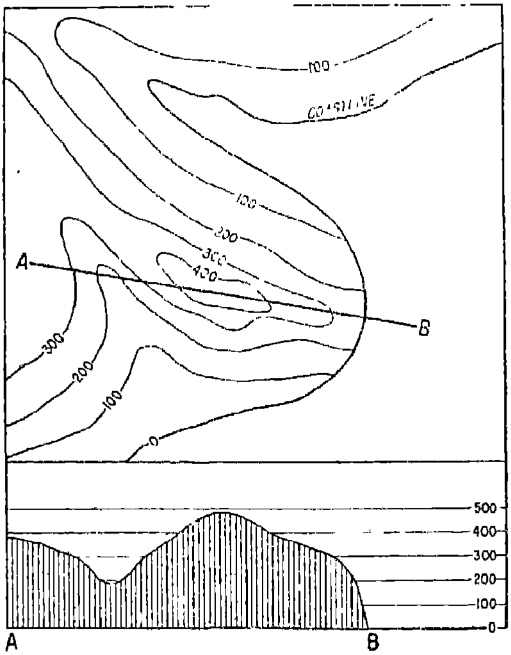

Fig. 45. A Cliff

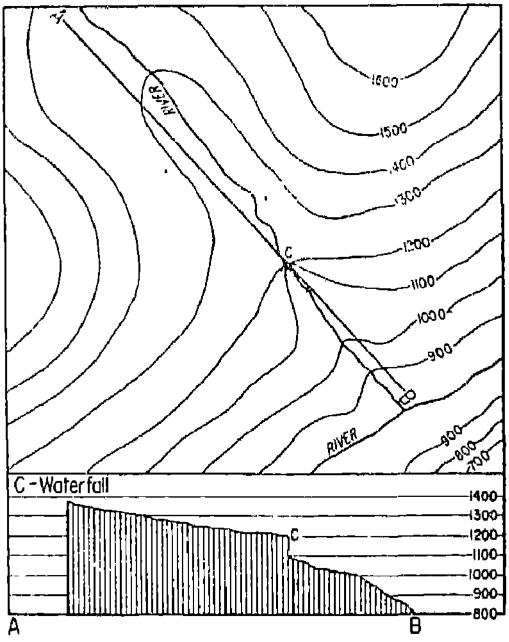

Fig. 46. A Waterfall

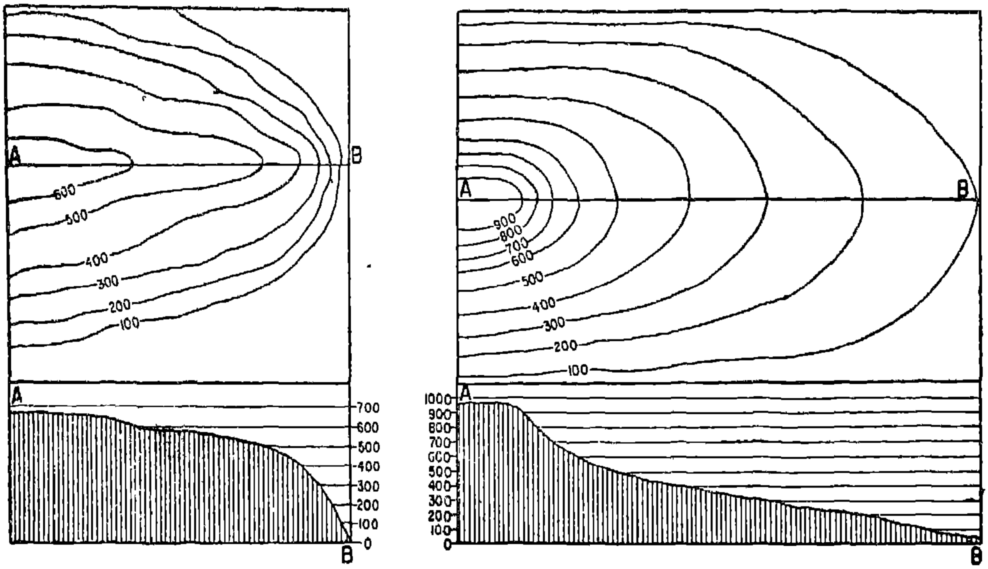

Fig. 47. Convex and Concave Slopes

along a given line, but they also help us in visualising more vividly the configuration of the surface.

For drawing a section, take any two points A and B on the map. Join them to form a straight line AB. Take a graph paper with a straight edge and place it along AB. Make pencil marks on the edge of the paper at points wherever it cuts contour lines. Note carefully the height of each contour line against each pencil mark. Draw perpendicular lines on this line AB from each of the pencil marks. After choosing a suitable scale, say, one centimetre for 100 metrés, mark the height of each perpendicular line to represent the height of the corresponding contour line. Now, by joining the tops of these perpendiculars with smooth continuous line you get the required cross-section or profile. It must be remembered that in such cross-sections the vertical scale is very much exaggerated in comparison to the horizontal scale (Fig. 48).

Interpretation of Topographic Sheets

The heads under which a topographic sheet is usually interpreted are : (i) marginal information, (ii) relief and drainage, (iii) land use, (iv) means of transport and communication, and (v) human settlements.

Under 'marginal information', answers to the following questions are generally sought : What is the name and number of the sheet ? Which specific area does the sheet depict ? What is its latitudinal and longitudinal extent ? Who are the publishers of the sheet ? When has it been published and on what scale ? What is the approximate total area of the region covered by the map ? Are there any special facts of physical and human geography ?

The common questions raised under the head 'relief and drainage' are : What is the contour interval used in the given sheet ? What are the prominent physical units into which the region can be conveniently divided ? How can these different geographical units be described ? What are the major landforms, such as plains, plateaus, valleys and hills, represented on the sheet ? Are there any characteristic features of these landforms ? Is there any prominent water divide in the region ? Are there any peculiari-

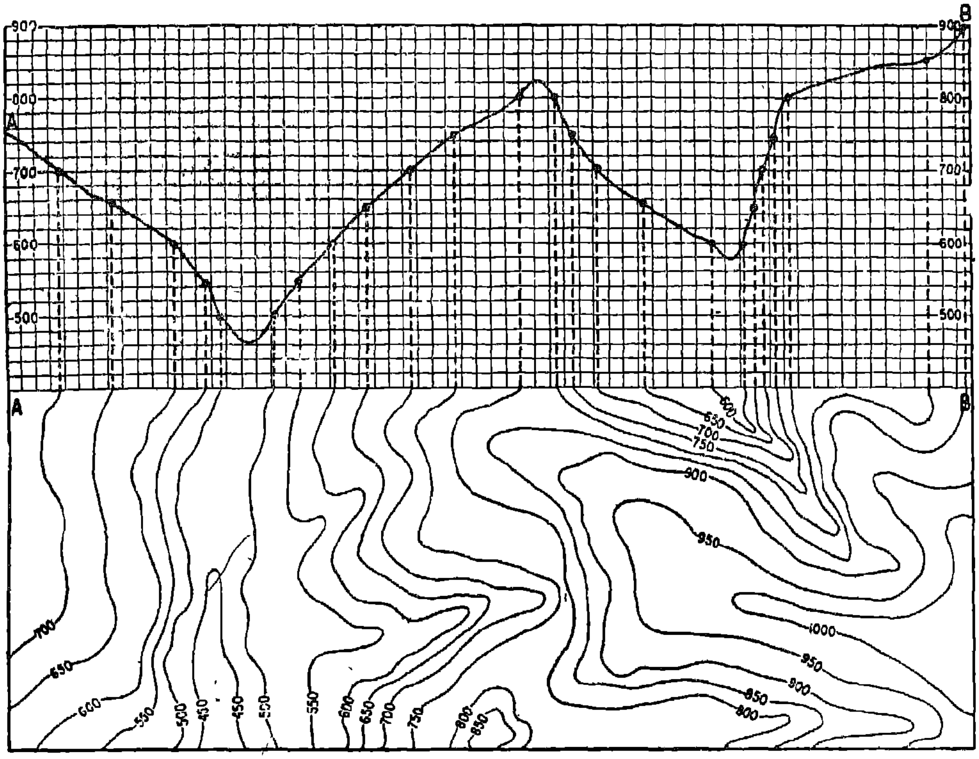

Fig. 48. Drawing a Profile from a Contour Map

ties in the drainage system ? Can anything be said about the general slope of the region and the gradient of the prominent river ?

The next aspect of the study deals with "land use" and, therefore, an attempt has to be made to elicit information regarding types of vegetation, and possible clues regarding climatic conditions and probable occupations of the people in the region. The questions pertinent in this regard are : What is the natural vegetation found in the region ? What are the important ways in which the land is used ? What are the possible major occupations, or sources of livelihood of the people ?

The information on "means of transport and communication" is sought from the given sheet through such questions as : What are the different means of transport in the region ? Is the area served by railways and roads ? How adequate are they ? Are there telegraph and telephone lines besides post offices ? What do the various lines of transport and communication indicate regarding the growth of urban and industrial centres ? Is there any correlation between the topographical features and the main lines of communication ? Is there any relationship between the means of transport and the patterns of settlement ?

The next query pertains to "human settlements". The information on this point also throws light on land use and occupations of the people. The questions that are useful in this regard are : Which are the urban centres in the region ? How big are they ? In what activities do they specialize ? Are they industrial, commercial or administrative centres ? How favourable are the locational factors for their growth ? How dense are the rural settlements ? Are they uniformly distributed ? Are the settlements nucleated ? Why are they so ?

Map Interpretation Procedures

First of all you will remember that description of the features shown on a map is only a prelude to map interpretation. The latter involves a study of the factors that serve to explain the causal relationship among several features shown on a map For example, the distribution of natural vegetation and of cultivated areas on a topographical map can be better understood against the background of land forms and drainage. In hilly and rugged areas, you might be able to establish a relationship between areas under different types of land uses and the slopes by drawing a profile across selected valleys reaching up to the hill tops or ridges on either side. Likewise, the distribution of human settlements in different regions has certain characteristics of its own by which it can be differentiated from others. In relatively plain areas, as in the Gangetic plain and parts of the Peninsular plateau of black soil, the settlements are spread relatively uniformly over the entire area mainly because of the opportunity for cultivating the land in most parts. In such areas, transport lines are also more in number and they provide favourable conditions for some settlements to grow as nodes by the convergence of transport routes. They would appear on the map as relatively large sized settlements some of which could be towns and cities Where the rivers have vast flood plains or in areas of hills and valleys, the transport routes almost always follow the river courses rather than crossing them.

From these considerations the following stages in map interpretation are suggested :

1. Find out from the index numbers of the topographical maps the location of the area in India. You may refer to the index map of topographical sheets as shown in Appendix III. This would give you an idea of the general characteristics of macro and meso level physiographic divisions from which a small portion of the area is presented on a large-scale map such as of one inch to a mile Note the scale of the map and the contour intervals. The latter are useful in describing the general characteristics of landforms with considerable ease.

2. Trace out the following features on five tracing sheets separately :

(i) Major land form features such as ridges, isolated hills, and eroded lands as shown by contours and other graphical features.

(ii) Drainage and water features, i.e. the main river and important tributaries, tanks and wells, if they are numerous and conspicuous on the map.

(iii) Land use, i.e. forests, grass and scrub lands, limits of cultivated areas and uncultivable lands such as rocky wastes. Limits of cultivation can be traced by either marking off all the areas coloured yellow (if it is a coloured edition) or by following the limits of cultivation shown by pair of dots placed at regular intervals as indicated on the map. Study of contours would help in ascertaining the accuracy to the extent permitted by the scale of the map.

(iv) Settlement and transport pattern.

3. Describe the distributional pattern of each of the features separately drawing attention to most important aspects.

4 Superimpose pairs of these maps at a time and note down the relationship, if any, between the two patterns, e.g. maps of contours and land use, and a map of settlement and transport pattern and that of land use or land forms or both. Aerial photographs of the same area can also be superimposed on the topographical map of the same scale to enrich the knowledge of the area which may not be readily understood on a topographical map alone.

Based on these maps, the original map and the notes, complete the exercise of map interpretation in which an attempt is made to describe and explain the patterns of distribution of different features.

Interpretation of Selected Topographical Maps

A few plates from the Survey of India one-inch topographic maps are expected to be studied carefully at this stage. These plates are only small portions of big sheets and are included in the Practical Geography Textbook published earlier by National Council of Educational Research and Training, New Delhi. Two or three plates from each sheet are to be studied with a view to giving an idea of as large a portion of the sheet as possible by fitting them together.

The sheets that have been selected for study represent different regions of India, e.g. a part of Thana district in the coastal strip of Konkan, a portion of Chingleput district, Tamilnadu, on the eastern coast, the edge of the Vindhyan plateau and the part of the Gangetic plain around Mirzapur, Uttar Pradesh, a portion of Aravalli hills, south of Ajmer, in Rajasthan, and a part of Siwalik hills between Chandigarh and Kalka.

The Low-Lying Valley of The Ulhas River

This is a portion of a one-inch topo-sheet No. 47E/4 published by the Survey of India. It represents a part of Thana district, Maharashtra. The tidal estuary of the Ulhas river is the important physical feature of this area. The river falls into Bombay harbour in the west only a few kilometres further downstream. Some life-lines that sustain the metropolitan city of Bombay pass through this area.

The area shown on the map ranges between 19° 10′N and 19° 15′N and between 73°E and 73° 5′E with a total area of about 100 square kilometres or 40 square miles. The region can be divided into two physical units · (i) the low lying Ulhas valley, and (ii) a north-south ridge in the south-west rising sharply over the surrounding lowland.

Most of the region except the ridge in the south-western part is less than 50 feet (about 16 metres) above sea level. However, the region is not a dead level land, rather, it is undulating with small hills and spurs on either side of the river.

The meandering course of a river suggests that the river is in its lower course flowing in a fairly flat region. Throughout its course, the banks are marked with a low water-line and a high water-line. This indicates the tidal nature of the river.

Note the symbol used for showing tidal limit. The marshes along the river are due to tidal waters. Many of the small streams joining the river are only seasonal streams beyond the tidal limit. This further indicates that the perennial nature of several streams is primarily determined by the tidal limit.

The hills in the south-western part are a good example of a ridge. Describe the trend of the crest line, not the peaks and their heights, measure the length and the width of the ridge, and draw a cross-section along the tunnel passing through the Dhup Dongar. In the local language of this area, the word dongar means a large hill.

What vegetation do you notice in this region ? Where would you look for tidal flora ? Which are the main lines of communication ? How adequate are they to serve the local needs ? Can you draw any inference regarding the nature of the traffic ?

In what way does the relief of the region influence the course of the major lines of communication ? Study carefully the impact of the river Ulhas and the ridge on the railway lines and the national highway.

Besides the lines of communication, which are the other life-lines of the metropolitan city of Bombay that pass through this area ?

How dense are the rural settlements ? Which is the most important natural resource in the south-western part of the area ?

Are there any urban centres in this area ? How would you account for this particular situation ?

Kalyan : A Nodal Town

The nodal position of Kalyan town is the important feature of the area shown on this sheet. In the past, it was an important administrative centre commanding the approaches to the Bor Ghat and the Thal Ghat, one to its north-east and the other to the south-east in the Western Ghats. In the local language, the word ghat means a pass. Today, the town stands at the junction of the railway lines that pass through these ghats and connect Bombay with the rest of India.

Study the latitudinal and longitudinal extent of the area shown on the map and find out its position in relation to the region shown on the previous sheet.

How would you describe the general relief of the area ? Would you call it an undulating plain with isolated hills ?

On what river is the town situated ? Is it a tidal river ? Note that the banks of the river near the town are steep with a height of 10 to 19 feet. Is there any other stream in this area ? Is it a perennial stream ?

There are a few tanks in the town. Some of them are shown in blue while one is not. What does it indicate ?

What type of trees do you find in this area ? Do you notice any change in vegetation on this and on the previous sheet ?

If you study both the plates, you would notice that there are only two road-bridges across the river Ulhas. One is in the vicinity of Thana in the west and the other near Kalyan. What natural factors are in favour of constructing bridges at these places ? Do you think that the town of Kalyan can depend upon the river for its water supply ?

As many as seven metalled roads and three railway lines of national importance meet at Kalyan. Trace the various railway routes and roads converging on this town. Study carefully the relationship between these lines of communication and the local physical features such as the river and hills lying to the south and south-west of Kalyan. Locate the various power lines, pipe lines, telephone lines, etc. on the map.

Note carefully the railway-cuttings and embankments. What symbols are used to show a cutting, an embankment and a tunnel ? What idea do you get from them regarding the nature of the terrain ?

The rural settlements are sparse but fairly big and compact. They are connected with the main roads by cart tracks. What symbols are used to indicate metalled roads, unmetalled roads and cart tracks ?

Arani : A Coastal Lowland

This is another sheet depicting a coastal lowland. It is a portion of topographic sheet No. 66 C/3. The area shown on the map is in Chingleput district, Tamil Nadu. The city of Madras is only about 26 kilometres south of this area. Tank irrigation is an important feature of this predominantly agricultural region. Locate this area on a map of India in your atlas with the help of the latitudes and longitudes given on this sheet.

How would you describe the nature of the terrain ? How does it differ from that of the previous sheet ? This is an example of a gently rolling lowland with a couple of isolated knolls. Note the height of the knoll south of Manjankaranai. The region as a whole has a gentle slope towards the east. How do you infer this ?

Name the two rivers flowing through this area. Are they perennial streams ? What inference can you draw from this fact regarding the seasonal local distribution of rainfall ? The rivers have mostly steep banks. What type of terrain does it suggest ?

Which is the largest tank in this region ? Is it a perennial tank ? Is it a natural or a man-made feature ? There are quite a few tanks scattered all over the region. Some are small, some are big. Most of them are natural tanks with a perennial water supply. What makes you think that tank irrigation is very important in this area ? Are there also wells in this region ? What symbols are used to indicate lined and unlined wells ? Which type of wells are predominant ?

Note the banana plantations in this area. What are the other trees ? What types of natural vegetation are found in this region ?

See the road running north-south almost in a straight line across the region. It generally indicates that the region is flat and devoid of major physical obstructions. Find out how level the road is with the help of bench marks plotted along the roadside.

Study the settlements. Are there any urban settlements in this area ? Which is the largest settlement shown on this sheet ? What factors favour its location ?

Do you find any relationship between tanks and the location of settlements in this area ? What does it suggest ?

Ponneri : A Coastal Lowland

This sheet is in continuation of the previous one, and represents the adjoining area in the east. The area shown on this map is similar to the previous one in most respects. However, a careful study of this sheet and its comparison with the previous plate would reveal a few differences.

Find out the location of the area represented on this map in relation to that of the previous sheet.

The sheet represents a flat lowland with a very gentle slope towards the east. Most of the region is less than 50 feet above sea level. Find out the lowest elevation marked on the map. Where would you look for the lowest point on your sheet ?

Compare the river courses as shown on the two sheets. The river-beds are dry for a part of the year, although they possess fairly wide channels. The presence of islands in the river channel indicates a very low gradient of the river. The river banks are steep with their heights ranging from 10 to 15 feet.

The region is studded with perennial tanks. Many of the tanks are small in size as compared to those on the previous sheet.

Vegetation in this region is varied. It consists of grasses, palmyras, other palms and deciduous trees. The coconut palms, banana plants and casurina trees seem to be of economic significance. Compare the vegetation in this region with that of the previous sheet. Is it more thick or sparse ? What does it suggest ?

Compare the railway lines shown on this sheet with those on the first two plates. How do these railway lines differ from those? Study carefully the symbols used to indicate broad gauge double line, broad gauge single line, metre gauge double line, and metre gauge single line rail tracks.

Note carefully that there are embankments all along the railway line. What does it indicate as regards the nature of the terrain ?

Compare the nature of traffic in this area with that of the first plate. What marked difference do you note in the two ?

Study the settlements shown on this sheet and compare them with those on the previous sheet. What inference can you draw regarding the density of population and the main occupation of the people ? What do you think are the main agricultural products in this area ?

The Vindhyan Plateau in Mirzapur District

The plate shows only a portion of a sheet No. 63 K/12. It represents part of Mirzapur district, Uttar Pradesh. The important physical feature of the area is a plateau region that is a continuation of the Kaimur hills of the Vindhyas, lying a few kilometres south of this region.

How would you locate this area on a map of India ? Would the latitudes and longitudes mentioned on the sheet help you in this regard ?

Note the maximum and minimum heights mentioned on this sheet. A bold contour line of 500 feet running across the region in the north and in the east is of significance in studying the relief of this area. Note the other three or four contours that are very close and almost parallel to it. What do they indicate ? They represent a steep slope. What is the amount of fall or rise near Rajghat in the north-eastern part of the sheet ? The sudden fall in the level of an elevated and fairly flat land, as marked by the closely set contours running almost parallel to one another, represents the steep edge of a plateau.

Study the land enclosed partially or wholly by the contour-line of 500 feet. What type of relief does it represent? Are there any residual hills on the plateau region? Describe them, if any.

Note carefully the zigzag shape of the contours that mark the edge of the plateau. What is it due to? Is there any relationship between the rivers and the shape of the plateau? A plateau that is interspersed with deep and numerous river valleys is called a dissected plateau. Would you describe this area as a dissected plateau? Substantiate your answer with specific examples.

Draw a section along the line joining Majhwani village in the south-east and the temple in Chitpur village in the north. Describe the major landmarks and landforms along this line with the help of the profile drawn by you.

There are two rivers in this region, one flowing in the west and the other in the east. In what direction do they flow? In what respect do they differ from each other? Note a big waterfall on the river that flows in the western part of the plateau. Name the fall and find out its height. Which is the largest tank in the region? Is it a natural or an artificial tank? Find out the length and the maximum height of its embankment.

What vegetation do you find in this region? Which is the favoured location for vegetation in this area?

There are three roads in this area. Study carefully the alignment of the road in the northern portion of the sheet. What is the impact of the relief of this area on the alignment of the road? Find out the length of this road in miles as well as in kilometres.

Note that there are no settlements in the two river valleys referred to above. However, there are settlements along the river and its tributaries flowing into the tank—Tandadari Tal. How would you account for this situation? What is the main occupation of the people in this area?

Mirzapur : A River Town

This plate is in continuation of the previous one as it represents an adjoining area in the north. The map represents typical features of the Gangetic plain in eastern Uttar Pradesh. The location of Mirzápur, an important river town in the region, adds to the significance of this sheet.

Locate the area represented on this sheet on a small-scale map of India with the help of latitudes and longitudes mentioned on this plate. State the location of this region in relation to the area shown on the previous sheet.

How would you describe the relief of this area? Note the value of the contour-line running along the southern margin of the sheet. Except for a few contour-lines in the south-eastern part of the region they are almost conspicuous by their absence. What does it suggest? Find out the minimum, maximum and average elevation of the entire region. How would you do it in the absence of contour-lines? In what direction is the general slope of the area? How does the relief of this region differ from that of the area shown on the previous sheet?

Observe the course of the two rivers running along the eastern and western margins of the sheet What does it indicate as regards the relief of the region through which they flow? What technical term is used to describe the nature of such a course?

Note the ravines in the western part of the sheet. What do they suggest?

Study carefully the channel of the Ganga river along the northern margin of the sheet. Compare the two banks of this river. What difference do you notice? Which terms would you use to describe these two types of banks? Remember that the river shown on the map is only a part of a big loop. The northern bank of the river is, in fact, the inner bank of the loop. Note the sand deposits on this bank. How steep is the southern bank? This is the outer bank of the loop.

Note the presence of deciduous trees in this area which give it the appearance of an open woodland.

Which are the major lines of communication that serve this area ? Note the alignment of the main railway line. What does its straight course indicate ? See how different metalled roads converge on Mirzapur town. To what extent is the river used for transport ? Where do you think is the maximum river traffic ? In what seasons is the pontoon bridge used for crossing the river ?

Note the size of the village settlements. Many of them are open but compact settlements of fairly large size. There are also a few permanent scattered huts. Are there temporary huts as well ? Do you find any relationship between the perennial tanks and the location of big villages ? Is there any correlation between the roads and the settlements ?

What do you think is the major occupation of the people ? What are the sources of irrigation in this region ?

What factors in your opinion favour the location and growth of Mirzapur town ? Why do you think that this town could not have been located on the northern banks of the river Ganga ? Compare the location of Bindhachal with that of Mirzapur. Which of the two sites is more favourable and why ? What makes you think that Bindhachal is a place of religious importance ?

A Flood Plain of the Ganga

This plate is a portion of topo-sheet No. 63 K/12 and is in continuation of the previous two plates. The map represents a portion of Mirzapur district and the southern tip of Banaras district. The meandering course of the Ganga river through its flood plain is the major feature of geographical importance in this area.

Fix the location of the area with the help of latitudes and longitudes mentioned on the sheet. Consult the scale and find out the length of the river course and its maximum and minimum width. Fit the two plates together in order to measure the exact length of the river.

The complete absence of contours on this map points out the smooth topography of the region. The monotony of this homogeneous region is broken by the meandering course of the Ganga. But for a couple of isolated knolls and a small patch of ravine lands in the north-eastern part of the region, the entire area presents a smooth topography. The knolls are shown by form-lines. How do the form-lines differ from a contour ? What special purpose do they serve ?

What indicates that the river has a very low gradient ? How would you account for the presence of sand deposits on the river bed and along the banks ? Note that there are no sand deposits where the river is confined to a narrow channel. On the other hand, large-scale sand deposits occur where the river spreads over a broad channel. Note that the sand deposits are generally found along the inner bank of a loop where the velocity of water current is usually low as compared to what it is along the outer bank. The loss of the velocity of river-water decreases its capacity to carry load, leading to the deposition of sand in the river bed.

River banks are steep along the outer bank of a loop as the river water moves very fast along this bank causing lateral erosion. The banks are shelving along the inner bank of a loop.

Note that the trees in this region are few. They are, however, found along the metalled roads. In the north, there are some orchards or plantations, perhaps mango groves.

A railway line runs along the northern margin of the sheet. One of its branches runs north-south up to the Ganga river. The name Mirzapur Ghat Railway Station (see previous plate) suggests the importance of Mirzapur town on the opposite bank of the river. It is metre gauge, single line track. A metalled road also runs parallel to the railway line, and crosses the river by a pontoon bridge.

Compare the settlements on the two sides of the river on this and the previous sheet. How would you explain the sparsity of settlements in the major part of this sheet? The settlements are again fairly dense in the northern part of the region. What does it indicate? How would you explain the presence of large size compact villages along the northern bank of the river on the previous sheet when most of the area is without settlements?

Aravalli Hills in Ajmer District

This is a portion of topographic sheet No. 45 J/8. The map represents a part of Ajmer district in Rajasthan. The part of the Aravalli range passing through this area is the significant feature of this region. The Aravallis are one of the oldest mountains on the earth. Today, they represent only the remnants of a once lofty mountain chain.

Note the latitudinal and longitudinal extent of this sheet and calculate the total area represented on the map. Locate this region on a map in your atlas.

Based on its relief, the region may be divided into four separate units—the north-western hilly region, the broad valley region, the elongated hilly region, and the south-east plain. All these units run parallel to one another. The broad valley region and the elongated hilly region are the important units.

Draw a cross-section along a line joining the north-western and south-eastern extremities of the sheet. Name the roads, rivers and the crest of the ridges along this profile.

The extensive water divide between the streams flowing north-west and south-east is narrow and long with sharp slopes on both sides. Can you calculate how high these escarpments rise above the base of the hills? The average elevation of the water divide is 1,850 feet above sea level. Trace its crest line.

The north-western hilly region is a ridge with a rather low elevation. The spot height of 1,673 is the highest point of this ridge. What is the contour-interval used on the map?

What type of topography does the broad valley region and the south-east plain present? Is it very flat, gently sloping in one direction or undulating? What is its general elevation?

The streams in this region are all seasonal except one which is fed by man-made perennial tanks.

Most of the plain area is under cultivation. From the seasonal nature of the streams, it can be inferred that there is inadequate rainfall in this region. It has to depend on irrigational facilities as is clear from tanks, embankments and wells all over the region.

With the exception of two wooded areas, trees are very sparse. What vegetation do you find in this region?

The region is mainly served by cart tracks. How many main routes cross this region? Correlate these lines of communication with the physical features of the area.

Note the size of the settlements. They are large and compact, but clearly indicate the sparsity of population.

Beawar—Location of a New Township

This plate is in continuation of the previous sheet, as it depicts the adjoining region in the west. Besides Ajmer district, the area shown on the map also includes a part of Pali district of Rajasthan. The city of Ajmer is only 29 kms, north-east of this region. The nodal position of the township of Beawar (Nayanagar) is a significant feature of the area represented on the sheet.

Stretching between 26°5'N and 26°10'N, and between 74°15'E and 74°22'E, the region covers an area of about 40 square miles or 100 square kilometres.

Locate the highest and lowest points on the map. What is the difference in their elevation? Examine carefully the contour-lines and spot heights given on the map. Shade lightly the land over 1,500 feet in height and thus locate the hilly areas on the map. Can you divide the area into different physical units? How would you describe them?

Except for a few small isolated hills and knolls, the broad valley region has a smooth topography. The few hills, however, rise more than 200 feet above the surrounding region and they are more or less rounded at the top. What is the general elevation of the valley region? Where are the ravine lands in this area?

The main streams of this region are the tributaries of the Makrera river. Are these streams seasonal or perennial? Note the valleys of the streams in the hilly area. Does the spacing of contours give any idea regarding the shape of these valleys and the steepness of the hills? To what extent is the hilly region dissected by streams?

Note the man-made features that aim at improving the drainage system of this area. How are the embankments shown on the map? Are they very common in this area? The drainage pattern in the south-western part of the area presents an interesting feature. The streams radiating in all directions represent a radial pattern of drainage. The radial drainage found in this area is, of course, on a very small scale and is true only locally.

What vegetation do you find in this area? The wooded area on the western hills is limited in extent. Why is it so?

The region is fairly well served with modern means of communication. Discuss the influence of relief on the roads and railways in this area. What physical features are followed or avoided by a route in order to maintain the most even gradient? Draw a cross-section along a line joining Sardhna and Chang villages and mark the positions of the railway line and the road on the profile.

Beawar (Nayanagar) is the only urban centre in the entire region. It draws upon the agricultural resources of the surrounding country. How far is it from its old site? Is it a major route-centre? How many and how important are the routes which meet here? How big is the settlement? Compare the sites of Beawar and Beawar (Nayanagar). Find out the latitude and longitude of Beawar (Nayanagar) and locate it on the map of India.

Except Beawar (Nayanagar), the settlements are rural in character. These rural settlements are of two types—the scattered huts and the compact villages. Study carefully the general pattern of the distribution of population. Is it dense or sparse?

Siwalik Hills in Ambala District

This is a portion of sheet No. 53 B/13. It represents a part of Ambala district. The hills which occupy most of the region shown on the map are a part of Siwalik hills, the foothills of the Himalayas.

Note the latitudinal and longitudinal extent of the region and locate it in relation to Chandigarh.

Find out the maximum and minimum heights shown on the sheet. In what direction is the general slope of the land? How would you divide the region into major physical units?

Observe carefully the highly dissected nature of the hilly area. How high are the hills from the base? How steep is the slope of these hills? Do you notice any escarpments in the area? Where are they found? Give a few examples.

Mark the narrow but flat valley bottoms with meandering streams. Sukhna Choa and the main tributaries of Patiali Rao are good examples of these streams.

Notice that all the major streams are almost parallel to one another flowing from north-east to south-west across the ridge. All the streams appear to be busy in headward erosion pushing back the water divide. Observe carefully the streams that extend up to the eastern and north-eastern margins of the sheet.

Study carefully how the nature of the streams changes as soon as they descend on the plain. How would you account for the sudden widening of the riverbeds, their braided course and the formation of islands in their channels? Note the gullies or ravines along the streams in the plain. This indicates that the plain consists of alluvium deposits brought down by the rivers from the Siwalik hills.

Note that there is very little vegetation even in the hills. This is another indication of how badly eroded the hills are.

Do you see any metalled roads in the area ? Even the cart tracks are confined to the south-west part of the region which is a plain or a valley bottom Note the camel tracks along the foot of the hills Similarly, the camel tracks may be found in the hills, but only along river-beds. There is only one footpath in the hills.

The important village settlements are in the plain and along the foot of the hills. These settlements are compact but far apart, indicating the relative poverty of the region. The settlements in the hills consist of scattered huts and these too are extremely sparse. There is not a single town in the entire region.

Pinjaur : A Valley in the Siwaliks

This plate is in continuation of the previous one as it represents an adjoining area in the east. The map represents a tract lying to the north-east of Chandigarh. A valley in the Siwalik hills is the important feature of this sheet.

Note the latitudes and longitudes of this area to locate it on a map of India in relation to the previous sheet. Find out the total area of the region represented on the sheet.

Into how many physical units would you divide this region and how would you name them ? Draw a cross-section along a line joining the north-east and south-west extremities of the sheet. Show the locations of a railway line, a metalled road, the river channel and the forests on the profile.

Describe the crest line—its trend and the heights of its peaks—in the south-western parts of the area. Compare the slopes on the two sides of this line. Would you call this line a watershed ? If so, why ?

How do the hills in the east differ from those in the south-west ? Find the highest elevation shown on the map. Note the triangulation stations on the peaks of some of the hills.

Study carefully the profile of the valley of the Jhajra river It presents a good example of an asymmetrical valley, i e. one of the valley sides being very steep as compared to the other. Which side of this valley is very steep ? How gentle is the slope of the other side ? Note that all the important tributaries of this river are flowing from the eastern hills.

Note the seasonal character of these streams including the Jhajra. Yet they must be carrying a large amount of water during the rainy season. What makes you think so ?

When these hill streams are active in the rainy season, their field of activity is not confined merely to carrying water. They are responsible for land erosion on a very large scale. What symptoms of land or soil erosion do you notice on this sheet ?

Note the gullies and ravines carved out by the streams along the southern margin of the sheet. Observe carefully the presence of islands in the channel of the Jhajra and its tributaries How would you account for their presence ?

Another interesting feature of the drainage is the braided channel of Koshallia Nadi. It further suggests that the hill streams carry a large load with them which they deposit on their bed when the velocity of water slows down owing to the low gradient of the river.

The river Koshallia is only a seasonal stream in its lower course. In its upper course, however, it is a perennial stream. How would you explain this phenomenon ? Study carefully the area where a perennial stream gives place to a non-perennial one. Mark the streams that disappear instead of joining the Koshallia down below. This indicates the presence of alluvial fans in this area where water sinks down the sand. This explains how a perennial stream in the hills suddenly becomes only a seasonal stream on entering the plain.

What vegetation do you find in this area ? Note the reserved and state forests.

Describe the lines of communication in this area. Do you think that they are meant to serve the local needs ? Correlate the main lines of communication with the relief features.

The presence of a fort-cum-palace at Pinjaur explains its historic importance and the picturesque location. Pinjaur is the only town in this area It seems that it grew because of the palace. Would you call it a collecting and distributing centre of the area ?

But for a few villages, the settlements are mostly in the form of scattered huts. There are a few settlements in the valley. But they generally avoid being close to any river. There are quite a few villages in the forested hills of the east. Do you think that the people in this area prefer to cling to the hillside rather than to the valley bottom ? If so, why ? Observe a large number of camel tracks and footpaths in the hills. Are the forest resources important in this region ?

EXERCISES

1. Answer the following questions :
    (a) What are the different types of maps ?
    (b) What is meant by "setting a map" ?
    (c) How does a cadestral map differ from a topographic map ?
    (d) Explain what map interpretation is.
    (e) What are the common headings under which a topographic sheet is interpreted?
2. Write short notes on :
    (a) Wall maps.
    (b) Marginal information.
    (c) Topographic sheets.
    (d) Relief maps.
3. If you are studying a topographic sheet depicting settlements, what information would you like to seek from the map ? What specific questions would you raise to draw precise information ?
4. Study carefully the sheets given in the text and answer the following questions :
    (a) With the help of the scale given on the map, measure the actual distance between the two meridians of longitude 5′ apart as shown on the Arani sheet. Do the same for the Pinjaur sheet and compare your results. What inference would you draw from this ?
    (b) Compare the terrains represented on the Ulhas valley sheet and Ponneri sheet. How do they differ ?
    (c) How do the river valleys of the Ulhas, the Ganges and the Jhajra, as shown on the three different sheets, differ from one another ?
    (d) Compare and contrast the means of communication as shown on the Kalyan sheet and the Mirzapur sheet.
    (e) In what ways are the settlements in the Aravalli sheet different from those in the Mirzapur sheet ?
5. Draw the conventional symbols for the following :
    (a) Tidal limit (b) Steep river banks (c) A railway tunnel (d) Perennial tank, (e) Bamboos (f) A waterfall (g) A ferry service (h) Pontoon bridge (i) Orchards (j) Scattered huts (k) Lined wells and (l) Ravines.

FURTHER READINGS

MEUX, A.E., Reading Topographic Maps, University of London Press Ltd., London, 1960. pp. 6-80.

SINGH, R.L., and DUTT, P.K., Elements of Practical Geography, Students' Friends, Allahabad, 1960. pp. 4-9, 98-132 and 344-346.

BYGOTT, J., An Introduction to Map Work and Practical Geography, University Tutorial Press Ltd., London, 1962. pp. 1-7, 77-86, 99-102 and 106-154.

LOCKEY, B., The Interpretation of Ordinance Survey Maps and Geographical Pictures, George Philips & Sons Ltd., London, 1958. pp. 10-32.

MARTIN, H.W., Ordinance Survey Maps in Schools, Edward Arnold Publishers Ltd., London, 1960, pp. 51-71.

DINK, P., Map Work, Atma Ram & Sons, Delhi, 1958. pp. 1-4, 15-16 and 38-43.

FOX, C.S., Physical Geography for Indian Students. Macmillan & Co., London, 1942. pp. 46-51.

RENJEN, M.L., Map Reading, National Council of Educational Research and Training, New Delhi, 1963. pp. 1-2 and 23-30.

DEVERSON, H.J. and LAMPITT, R., The Map that Came to Life, Oxford University Press, London, 1948.

Chapter 5

STUDY OF WEATHER

WEATHER IS a subject of universal interest as it affects the life and conditions of the people everywhere. The uncertainties of weather have been our concern for many years. Till recently the observations of weather phenomena have not been systematic and were based on personal impressions or statements based on incomplete data. The science of meteorology, i.e. the study of weather and climate, has made rapid strides during the last decade. Meteorological stations all over the world record and exchange with one another data relating to weather through telecommunications. Artificial satellites are now being used to measure and interpret the weather phenomena, and it has become possible to predict more accurately the conditions of weather for a day, week, month or season.

There are a number of elements of weather that can be measured with a fair degree of accuracy. The important ones are: (i) temperature, (ii) pressure, (iii) winds, (iv) humidity, (v) cloudiness, and (vi) precipitation. These are the basic weather elements. A change in one weather element will, in turn, change some or all the others. Sometimes, one element may be more noticeable than the others. Hence, on the basis of a predominant weather element weather conditions can be generalised by referring to them as rainy, sultry, cloudy, windy or sunny.

Weather forecasts help us to take safety measures in advance in case of the likelihood of bad weather, viz. storms, gales, and heavy downpours. For instance, predicting weather a few days in advance may prove very useful to farmers and to the crews of ships. Similarly, prediction of weather only a few hours ahead may facilitate safe air flights. This is, at any rate, not a simple task. To do it accurately, the weatherman requires a number of weather instruments devised specially for the purpose. He needs to know how to use these instruments. He also requires weather information from neighbouring regions.

In this section we deal with the description and use of some of the common, but important, weather instruments.

Measurement of Temperature

The knowledge of the temperature of freely moving air is the primary concern of the weatherman because it is responsible for a variety of weather changes. The instrument designed to measure accurately the changes of temperature is called a thermometer which literally means "heat measurer".

The construction of a thermometer is based on the fact that any substance, whether solid, liquid or gas, expands in a particular manner when heated. Gases expand the most and are, therefore, most sensitive to heat but, at the same time, such a thermometer would be too bulky and, therefore, unwieldy. Consequently liquids are preferred as liquid thermometers are smaller and easier to read and handle. They are the most common type of thermometers for making surface weather observations. Ordinarily, mercury or alcohol is used as the thermometric liquid in standard thermometers.

A thermometer consists of a narrow sealed glass tube of a small uniform bore sealed at one end and with an expanded bulb at the other. The bulb and the lower part of the tube are filled with mercury. Before the other end is sealed off, the air in the tube is evacuated by heating it. The bulb of the thermometer in contact with the air gets heated or cooled, as the case may be, as a result of which the mercury in the bulb rises or falls. The changes in atmospheric temperature are indicated by the rise or fall in the level of mercury.

There are two fixed points marked on the stem of the glass tube. The lower one, immediately above the bulb, indicates the position where the mercury level would be when the bulb of the thermometer is immersed in a vessel containing melting ice, so that it would show the temperature of melting ice. Similarly, the upper end of the stem indicates the temperature of boiling water under normal conditions of pressure.

The length of the stem between the established boiling and freezing points is divided into equal divisions called degrees. The number of these graduations depends upon the nature of the scale used. The two most common thermometer scales in use are the Centigrade and the Fahrenheit.

On the Centigrade thermometer, the temperature of melting ice is marked 0°C and that of boiling water 100°C, and the interval between the two is divided into 100 equal parts. On the Fahrenheit thermometer, the freezing and boiling points of water are graduated as 32°F and 212°F* respectively and the interval between them is divided into 180 equal parts. Therefore, one Centigrade degree is equivalent to 1.8 Fahrenheit degrees.

In order to change Centigrade readings to Fahrenheit, Centigrade degrees are multiplied by 1 8 (or by 9/5) and 32 is added to it because the freezing point on the Fahrenheit scale is 32 degrees. On the other hand to change Fahrenheit readings into Centigrade, the process is reversed, i.e. 32 is first subtracted and the balance is then divided by 1.8 (or multiplied by 5/9). The following formula may be used for conversion from one scale to another.

(i) From Centigrade to Fahrenheit

$$F = (C \times 9/5) + 32$$

(ii) From Fahrenheit to Centigrade

$$C = 5/9\,(F - 32)$$

Example

The normal temperature of the human body is 36.9°C. Convert it to Fahrenheit.

$$\begin{aligned} F &= (C \times 9/5) + 32 \\ &= (36.9 \times 9/5) + 32 \\ &= 66.4 + 32 \\ &= 98.4^\circ F \end{aligned}$$

Six's Maximum and Minimum Thermometer

There are special thermometers that register maximum and minimum temperatures and also wet and dry temperatures. The purpose of a maximum and minimum thermometer is to record the highest and the lowest temperatures occurring during a given period. A record of the maximum and minimum temperatures in a given period is kept by the instrument itself (Fig. 49).

Six's Maximum and Minimum thermometer consists of a cylindrical glass bulb A, connected to a U-tube, BC, which terminates in another bulb D as shown in Fig. 49 The lower part of BC contains mercury. The parts of the limbs B and C above the mercury surface and the bulbs A and D contain alcohol as the thermometric liquid.

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*0° in the Fahrenheit thermomete coincides with the level of the mercury in the tube when the bulb is surrounded not by pure melting ice but by a mixture of ice and salt. It was then graduated upwards and found that the temperature of melting ice was 32° F and that of boiling water, at normal atmospheric pressure, was 212°F. This is how the Fahrenheit scale originated.

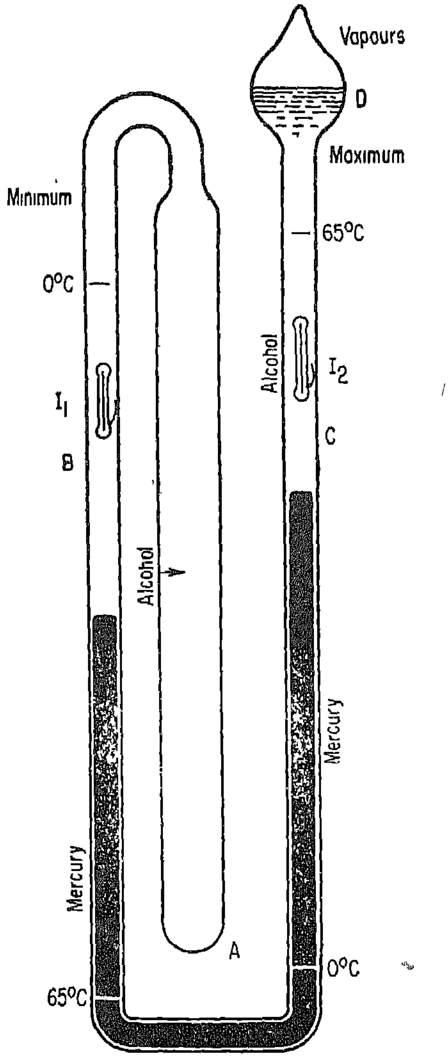


Fig. 49. Six's Maximum and Minimum Thermometer

Above the mercury surface in each limb, there are two steel indices, I_1 and I_2, each provided with a spring arrangement which keeps them pressed to the sides of the tube. To set the thermometer, each index is moved up or down the tube by a small horse-shoe-shaped magnet. With this magnet indices I_1 and I_2 are brought in contact with the mercury. This is called the setting of the thermometer. The thermometer is then ready for use.

Both the limbs of BC are graduated. The index attached to bulb A registers the minimum temperature with the scale of graduation running downwards from top. The index attached to bulb D records the maximum temperature with the graduations running upwards from the bottom.

With a rise in temperature, the alcohol in the bulb A expands pushing down the mercury surface in B. Naturally, mercury rises in the limb C pushing the index I_2 before it. When temperature falls, the mercury level in C falls, leaving the index I_2 at the same position. But this results in the rise of the mercury in B, and the index I_1 is pushed up until the temperature ceases to fall. Hence, the readings against the lower ends of the indices I_1 and I_2 give the minimum and maximum temperatures respectively, reached during the period of observation.

After noting the readings of maximum and minimum temperatures for the given period, which is usually a day, the thermometer is again set by bringing the indices I_1 and I_2 in contact with the mercury levels in the limbs B and C for the following day.

In meteorological observatories, the recordings of temperature are taken at fixed intervals every day. Nowadays, separate thermometers are used for obtaining the maximum and minimum temperatures. The maximum thermometers contain mercury, whereas the minimum thermometers contain alcohol.

The mean daily temperature is the mean of 24 readings taken at hourly intervals. This is almost the same as the average of the three readings taken at 6 a.m., 1 p.m. and 6 p.m., or the average of the three readings at 7 a.m., 2 p.m. and 9 p.m. The mean of the maximum and minimum temperatures of a day does not give the mean daily temperature and is generally larger than the mean of the hourly readings.

Wet and Dry Bulb Thermometer

The wet and dry bulb thermometer consists of two exactly identical thermometers fixed to a wooden frame. The bulb of the thermometer

T_1 is kept uncovered and is exposed to the air while the bulb of the thermometer T_2 is wrapped with a piece of wet muslin or cotton which is kept continuously moist by dipping a strand of it into a small vessel of water as shown in Fig. 50. When air blows over the instrument, the water from the wet bulb evaporates. The evaporation from the wet bulb lowers its temperature. Hence T_2 will record a lower temperature than T_1.

Dry bulb readings are not affected by the amount of water vapour present in the air, but the wet bulb readings vary with it since the rate of evaporation is dependent upon the amount of water vapour present in the air. The greater the humidity in the air, the slower the rate of evaporation and hence the difference between the readings of T_1 and T_2 will be small. On the other hand, when the air is dry, the evaporation from the surface of the wet bulb is rapid, which would lower its temperature and the difference between the two readings would be large. Hence, the difference of the readings of T_1 and T_2 determines the state of the atmosphere with regard to its humidity, the larger the difference the more arid the air is. Exact humidity can be determined by reference to specially prepared Tables.

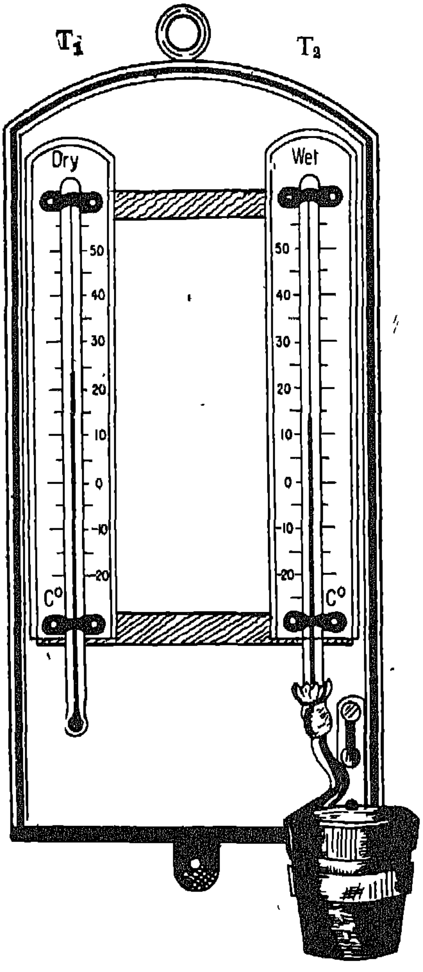


Fig. 50. Wet and Dry Bulb Thermometer

For correct wet and dry bulb readings, the vessel should be kept filled with distilled water. Care should be taken to change the muslin, at least once a month. When the weather is damp, the dry bulb thermometer should be wiped dry a few minutes before the time of observation.

The thermometers should be exposed neither to direct sunshine nor to reflected radiant heat. They are generally housed in a shelter, a double-walled cubical wooden box painted white. It has louvred sides, that is, open windows crossed by a series of sloping boards to permit free movement of air without direct passage of solar ray. It is kept at a height of about a metre and placed away from buildings in an area not enclosed by walls or trees. This type of shelter is in common use in meteorological stations in most parts of the world. In tropical countries, however, where heat is intense, huts with thatched roofs and open sides are generally preferred as shelters.

Measurement of Atmospheric Pressure

It is well known that air has weight, and that it exerts great pressure on the earth's surface. It has been found that at sea level, under normal conditions, the pressure of air is 14.7 lb on every square inch or 1.03 kg per square centimetre. As a result of the constant movement of air, the changes in temperature and the variation in its vapour content, the weight of the air above any point is continually changing. Therefore, like temperature, atmospheric pressure also varies with time and place. Although its variations are not so easily perceptible to the human senses, it is an important feature of weather study and forecasting because of its close relationship with other weather elements.

The instrument designed to measure atmospheric pressure is called a barometer. The principle of a mercurial barometer is explained by a simple experiment. Take a thick glass tube of uniform bore about a metre long and fill it with mercury. Close the mouth of the tube with a finger, then invert and immerse its open end in a cup of mercury without allowing air to enter in the tube and then remove the finger. The mercury will flow out of the tube into the cup and stand at a definite height above the level of the liquid in the cup. This is because the weight of the column of mercury in the tube, above the surface of the mercury in the cup, is balanced by the weight of the air column of an indefinite height exerted as pressure upon an equal cross-section of the liquid surface. The height of the column of mercury in the tube, therefore, becomes the measure of the pressure of air. The height of the column is graduated in millimetres or in inches (Fig. 51).

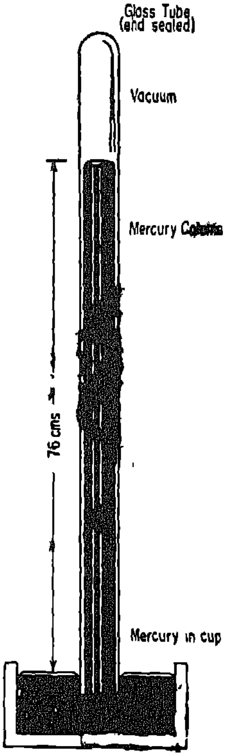


Fig. 51. A Mercurial Barometer

Fortin's Barometer

Like the simple barometer, the Fortin's barometer consists of a vertical glass tube containing mercury, the upper end of which is closed and the bottom open. The open end of this tube is inverted into a cistern of mercury. The cistern has a flexible bottom with an adjusting screw, S, to bring the mercury level in the cistern to a fixed point before taking readings. When the pressure decreases, some of the mercury flows out of the tube into the cistern. When the pressure increases, some of the mercury in the cistern flows into the tube. Therefore, to provide a fixed point above which the height of the column may be measured, an ivory index, I, is fixed to the top of the cistern. The zero of the scale corresponds to the tip of the ivory index which points down vertically (Fig. 52).

The barometer tube is encased in a brass tube, AB, for protection, and the scales indicating centimetres, inches or millibars of pressure are inscribed on it. It has a slit through which the mercury level in the tube can be clearly seen. The instrument is provided with a vernier, V, which slides in the slit. Its position is adjusted by means of the screw, T. There is a brass plate attached to the vernier and is behind the barometer tube. The lower edge of this brass plate and the lower edge of the vernier are in the same horizontal line and they move together when T is worked. There is also an attached thermometer. This thermo-

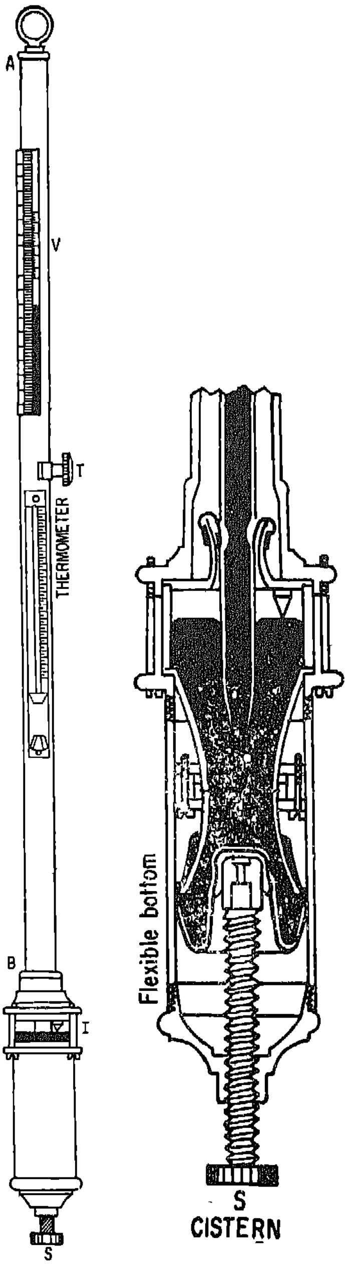


Fig. 52. Fortin's Barometer

meter helps to make a temperature correction for every pressure reading.

For using the Fortin's barometer, two adjustments are required before a reading is taken. First, by operating S the mercury level in the cistern should be made to just touch the tip of I, and its image as seen by reflection at the mercury surface should appear to be in a continuous line with itself.

Secondly, the zero of V should be made to coincide with the surface of the mercury in the tube. For this, the eye is kept in level with the horizontal line joining the lower edge of V and the brass plate behind it. The screw, T, is worked until the top of the mercury in the tube is in the same line as the lower edge of the brass plate and the vernier. The barometer is now ready for taking observations.

Aneroid Barometer

Another instrument in common use for the measurement of atmospheric pressure is the aneroid barometer. It gets its name from the Greek word, *aneros* (*a*—'not', *neros*—'moisture'), meaning without liquid.

It consists of a corrugated metal box made of silver or some similar thin alloy, sealed completely and made airtight after partial exhaustion of air. It has a thin flexible lid which is sensitive to changes of pressure. There is a spring inside the box which keeps the lid from collapsing under the pressure of the atmosphere and restores the shape when the pressure is reduced.

As the pressure increases, the lid is pressed inward and this in turn moves a system of levers connected to a pointer which moves clockwise over the graduated dial giving higher readings. With the decrease in pressure, the lid is pushed outward and the pointer moves counter-clockwise, indicating the lowering of barometer reading.

Furthermore, since air is a compressible substance, the lower layers are more compressed and, therefore, denser than the upper layers. Thus, a pressure reading taken at a higher level will exclude the densest layer of air which occurs below, and as a result of this reading will be less than at the bottom of the layer. These are of special significance in aviation and mountaineering.

An altimeter is a special type of aneroid barometer which is standard equipment for air pilots and mountaineers. It is graduated to read heights directly.

It has been observed that the normal atmospheric pressure at sea level is equal to the weight of a column of mercury 76 centimetres long. Pressure diminishes with increasing heights in arithmetic progression. That is, on an average, a fall of one centimetre in the barometer level indicates an elevation of nearly 110 metres above sea level, another centimetre fall in pressure for a height of 115 metres, and another for 120 metres and so on. This is readily observed in the first thousand metres of the atmosphere above the earth.

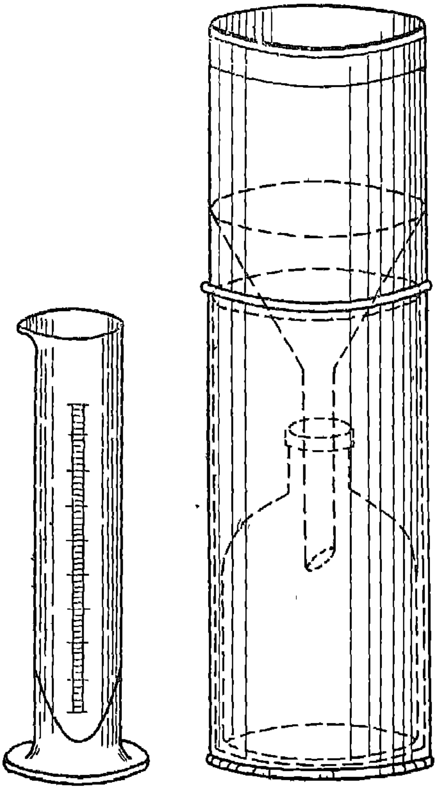


Fig. 53. A Rain Gauge.

Measurement of Precipitation

For measuring the amount of rain which falls in a locality during any interval of time, a simple instrument called the rain-gauge is used. There are many types of rain-gauges, but the object of all is to collect the rain water falling on an area and store it without allowing any loss by evaporation, run off, or seepage (Fig. 53).

The rain-gauge consists of a metal cylinder in which a funnel (see Fig. 53) fits accurately and directs the rain into a receiving vessel. The circumference of the mouth of the funnel is equal to the circumference of the base of the receiving vessel. The mouth of the cylinder is 12.5 centimetres above the mouth of the funnel, so as to avoid any splashing out due to the falling rain water. Automatically, all the rain water that falls on the surface area of the funnel flows into the vessel.

The water collected is measured by a measuring jar which is graduated either in millimetres or in inches. The area of the base of the measuring jar has a definite relationship with the area of the funnel. In India, we use millimetres or centimetres as the unit of measurement of rainfall. The reading is taken every 24 hours at a fixed hour of the day, generally at 8 a.m., and it shows the amount of rainfall on a given day.

For accurate readings, the instrument should be exposed in an open and level area 30 centimetres above the level of the ground to prevent splash. To allow free and unintercepted fall of raindrops in the rain-gauge, it should be placed far away from trees, buildings and other high objects. Also, it needs to be protected from stray animals as they are likely to overturn the rain-gauge.

Wind Direction and Speed

Wind is another basic weather element. Two facts about wind need to be observed with care, namely, direction and speed.

The usual method of determining wind direction is by means of a wind-vane. The vane is a revolving plate. This plate is perfectly balanced on a rod. There are ball bearings on which it turns smoothly without friction, so that it responds even to a slight blow of wind In its simplest form, the vane has a light thin metallic or wooden structure having a pointed end known as arrow (made of heavy metal) and a broad end called the tail.

The arrow always points towards the direction from which the wind blows and the tail helps in keeping the point of the vane nosed into, or towards, the source of the wind at all times even when there are gusts accompanied by frequent changes in the direction of the wind. Below the vane, the vertical rod carries a cross indicating the four directions.

Anemometer

An anemometer is the instrument used for measuring wind velocity. This 'wind-speed indicator' consists of three or, less commonly, four hemispherical cups attached by horizontal arms to vertical spindle

When the wind blows, the cups rotate making the horizontal arms spin with them. The rotary motion of the horizontal arms, in turn, causes the vertical spindle to rotate. At the bottom of the spindle, there is a mechanical device which records the number of its revolutions, and hence the velocity of the wind.

The anemometer is sometimes electrically connected to a dial inside the weather station. This dial indicates the speed of wind in kilometres, or miles, or knots per hour.

The place of exposure of wind instruments should be free from the interference of local irregularities. The wind instruments should be placed far away and also fairly above any adjacent high object. Exposures at airports or towers in the open are generally preferred.

A weather map gives, at a glance, a generalised picture of weather conditions that exist over a considerable area at some particular instant of time.

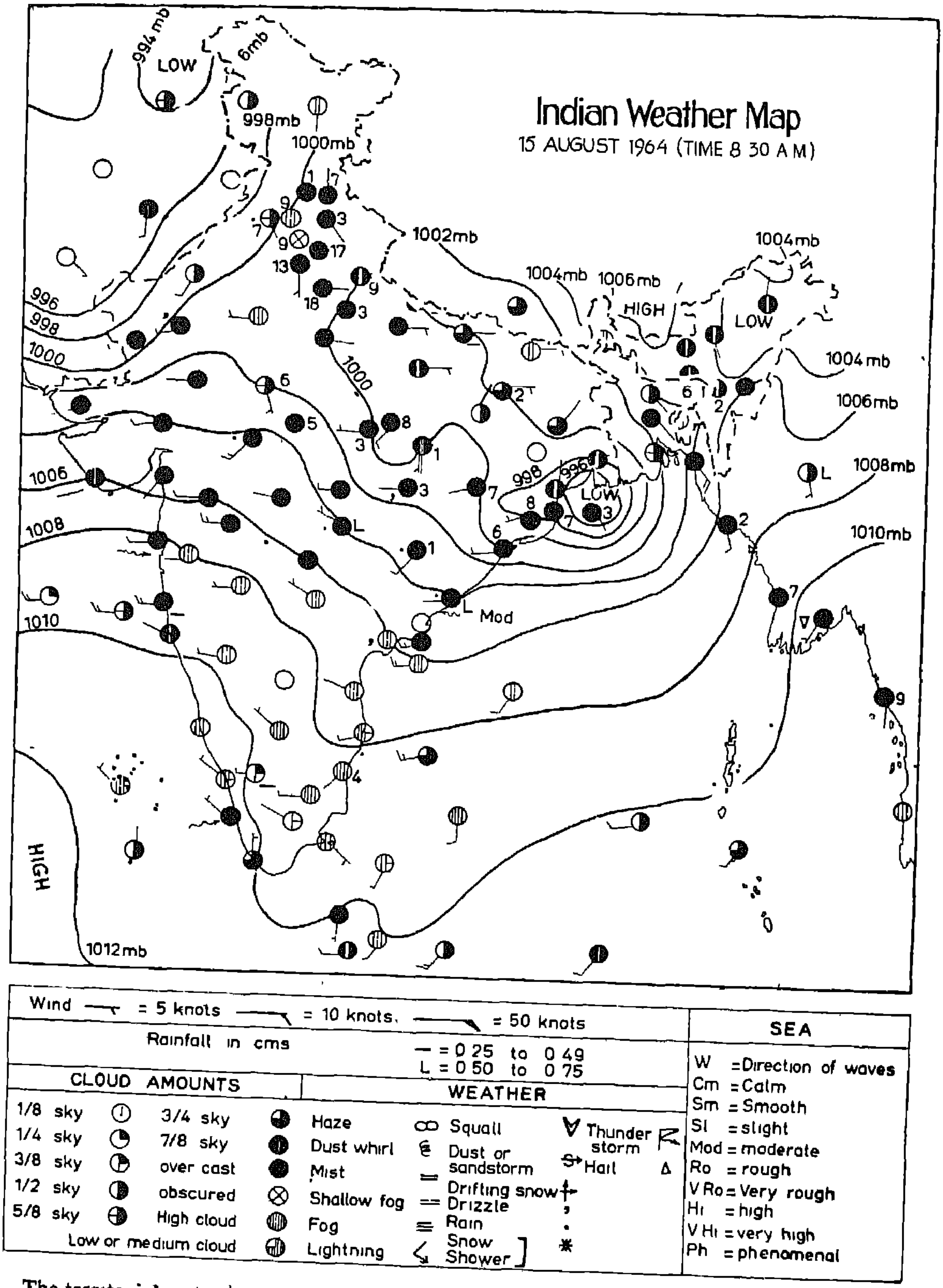
To construct such a map is by no means an easy job. Hundreds of observers are engaged in recording data simultaneously on a uniform pattern. They are also aided by highly sensitive self-recording instruments. The data are then collected and sent to central and regional observatories by telegrams and telecommunication channels without loss of time. In the central observatory these data are processed and depicted on a map known as the weather map. This is what the weather services or meteorological organisations do with the help of a widespread network of observatories.

Meteorological Service

A meteorological service in India was established in 1875 with its headquarters at Simla. After World War I, the Meteorological Department was expanded and its central office was shifted to Poona (Pune). The Indian Daily Weather Reports are published every day from this place (Fig. 54).

An Indian Daily Weather Report has a map of India which shows pressure distribution, wind direction and velocity, rainfall, sky conditions, and weather phenomena affecting visibility. It is accompanied by a daily weather report containing a summary of weather conditions that prevailed on the previous day and a forecast for the next 24 hours. It also contains data recorded at important stations all over India, the wireless reports received from ships in the Arabian Sea and the Bay of Bengal, and the upper air data regarding winds, temperatures and dew points for a few places. It is on the basis of these synoptic charts that the weather forecasts are made. Nowadays, satellites are used in getting the information and pictures of the clouds.

The accompanying weather map (Fig. 54) illustrates the conditions of weather as on August 15th, 1964, at 08.30 hours. Study the various symbols used to describe the wind direction and speed, amount of cloud and rainfall. The pressure conditions are shown by isobars. August is the month when the south-west monsoon establishes itself well over most parts of India and hence you notice that a cyclone has developed over the Bay of Bengal. It has



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Fig. 54. Indian Weather Map

moved north-west and under its influence most parts of central and north India have overcast sky and widespread rains The isobars tend to be closer over central India in accordance with the conditions of a cyclone to the south of Calcutta, marked by a low pressure area. This is where the isobars are the closest and the gradient is very steep.

Meteorological Observations

In India there are more than 350 observing stations grouped into five categories At one end of the scale stand Class I observatories equipped with self-recording instruments such as a thermograph (for temperature), a barograph (for pressure) and a hygrograph (for humidity). These observatories transmit data to the Central Observatory at Pune twice a day. At the other end of the scale are the Class V observing stations recording only the amount of rainfall, once every 24 hours. Besides these observing stations, valuable data are collected from the ships plying on the Indian seas. Weather forecasts are highly useful for air pilots, navigators, fishermen, defence personnel, farmers, horticulturists, people connected with flood control, and also the general public. It is for the benefit of all these people that weather bulletins are broadcast every day.

Man's concern for weather is perhaps as old as himself. The science of weather known as meteorology, however, came into its own rather recently with rapid advances in physics, mathematics, chemistry, geography, astronomy and mechanics. The invention of the barometer by Torricelli in 1643 and the thermometer by Fahrenheit in 1710 are important landmarks in its early development.

This science grew as a result of discoveries made by various scientists in their own fields. Even today, it is not an exact science. However, efforts are being made to break new ground. Establishment of observatories in Antarctica, the International Indian Ocean Expedition, the launching of rockets and weather satellites for collection of data from upper air and outer space, are some of the new landmarks in this direction.

Air Photographs and Satellite Imageries

The use of air photographs has made the task of preparation of specialised maps and their interpretation far more easy and accurate. The information on land use and other cultural features shown on the topographical maps becomes out of date very soon unless the maps are revised periodically. Air photographs of different scale are taken and the distributional patterns of various features are then transferred on the maps of the same scale in order to make them up-to-date Reading and interpretation of air photographs requires specialised training.

Air photographs are now being used in many countries for the purpose of landform and land use evaluation, in the preparation of city-development plans, construction of major development projects, etc.

Satellite imageries are now in use for global and country level studies of climate. Forecasting of weather has also become more accurate with the availability of meteorological data from the satellites. Mineral prospecting, preparation of land use inventories, and forecasting of agricultural production are making use of satellite imageries. India is one of the countries which is collaborating in this project at the global level.

EXERCISES

Review Questions

1. Answer the following questions :
   (a) What are the basic elements of weather ?
   (b) How does an Aneroid barometer differ from a mercury barometer ?

(c) Compare and contrast the Fahrenheit and Centigrade scales.

(d) Explain how relative humidity is determined.

2. Write short notes on :
   (a) A meteorological observatory
   (b) A shelter
   (c) An Indian daily weather report
3. Write in brief the story of an Indian daily weather map explaining the various stages involved in recording data, their collection at the central office, processing, and depiction on a map.
4. In what different ways are the weather forecasts useful to different people ?
5. Given below in the first column are certain functions to be performed and in the other the instruments that are available with you. Make out correct pairs ignoring the instruments that are of no use to you.

(a) Finding out wind direction	(a) A thermograph
(b) Automatic recording of pressure	(b) Six's thermometer
(c) Measuring velocity of wind	(c) A hygrometer
(d) Automatic recording of humidity	(d) A hygrograph
(e) Finding out atmospheric pressure	(e) An altimeter
(f) Taking the direct readings of heights	(f) A barograph
(g) Automatic recording of temperature	(g) A wind-vane
(h) Finding out humidity	(h) An aneroid barometer
(i) Finding out maximum and minimum temperature, for a given period	(i) An anemometer
	(j) Wet and dry bulb thermometer
	(k) Fortin's barometer

Map Readings

Study carefully the weather map given in the text and answer the following questions :

(a) Name the parts where the Highs and Lows lie.

(b) In what part of the country is the sky overcast ?

(c) State the maximum and minimum values of atmospheric pressure depicted on the map.

(d) Name the directions of winds off the Bombay coast and state their velocities.

(e) What are the symbols used for depicting : (i) Lightning, (ii) Thunderstorm, (iii) Snow, (iv) Dust-storm, and (v) Calm sea ?

Chapter 6

FIELD WORK

FIELD WORK constitutes an important aspect of geographical studies. It helps us in understanding the realities of man and his environment in his immediate surroundings. There are marked differences in social, cultural and economic characteristics not only between different regions of the country but in different strata of the society within a region. These are often influenced by the productivity of the land and occupations of the people, by the services and facilities available to the people and by their capacity to utilise them. The levels of income and expenditure on various items of daily needs also vary. Also, the pattern and the purpose of movement of people to different places are influenced by the differences in the levels of living of the people. All these aspects need field work by which we can collect first hand information and data and analyse them by various methods. The published data or the data compiled from other sources would not often be adequate or suitable for geographical studies, hence the need for field work by which we can generate our own data. Besides, field work provides us an opportunity to observe, to plot on a map and to interview the people about the distribution of various phenomena and to understand the causal relationship among them.

The approach to field work varies, depending upon the topic for investigation. The objectives of field work have also to be clearly stated. Field work involves observation and recording in the form of rough sketches or maps, compilation of data not normally published and also enquiry with the help of a specially prepared questionnaire.

Design of Field Work

Before conducting field work the area or topic of study should be decided and available information, maps, etc. collected. A base map of the area should be prepared for the purpose of plotting the data on the map with appropriate cartographic techniques as explained in Chapter 4. You may need several copies of the map. Questionnaires and schedules have to be prepared for data collection. The large-scale topographical maps of the area may be consulted for understanding the characteristics of the area in terms of relief, broad land use, settlement pattern, transport and communications. Often, it may become necessary to conduct field work by choosing an appropriate number of samples rather than conducting a total survey which is time consuming. For example, if there are 1,000 fields in a village you may have to select say, 100 fields for detailed investigation. In that case, it is called a sample survey of land use of a village with 10 per cent sampling.

The following examples of field studies are intended to provide you some idea of the design and procedure for field work. It is expected that with the help of your teacher you would select at least one topic which appears to be most interesting in the place where your school is located. For example, in a school in a small town or a large village situated in an agriculturally rich area, the field work project could be on land use in a village close to the school. If it is a forested and hilly area or a coastal area, the project could be on the study of land forms. If you are situated in a metropolitan city with an industrial base, the topic for field work could be the study of an industry. Likewise, a town provides good opportunity for the study of its market. A study of the catchment area of the school will be rich in diversity and rewarding if your school is in a metropolitan city, where the school children are scattered in different parts of the city and come from different socio-economic backgrounds. Talking to your classmates or pupils from other classes in the school and collecting the required information as explained in the project design, would help you to know more about the school as a live entity in the midst of several functions which the city performs.

Land Use Survey

Field work for land use studies can be taken up for the entire village or a part of it depending upon the size of the area to be covered. A village land use survey basically involves mapping all the types of land uses on a map of the village (cadestral map) which shows the field number and boundaries of fields (Figs. 55 and 56). The types of land use are then plotted on the map as you move from one field to the other from a fixed point which is identified on the map before you start the field work. You may use code numbers or abbreviations while plotting the land use. For example, you may write P for paddy and W for wheat and so on.

On a separate map, mark the soil type according to colour and texture, and make notes about the general character of the field in terms of the slope and drainage and whether the crop is irrigated or unirrigated. Next comes the enquiry with the farmers who cultivate these lands. For this purpose, you will need a schedule in which you will fill up the various columns by gathering information from the farmer.

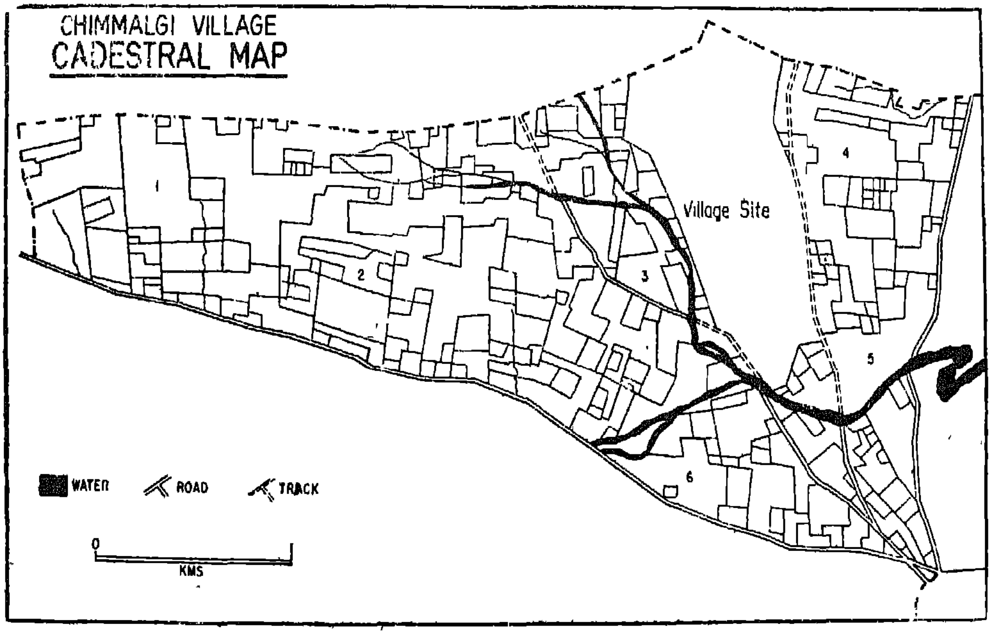


Fig. 55. Cadestral Map with Field Boundaries

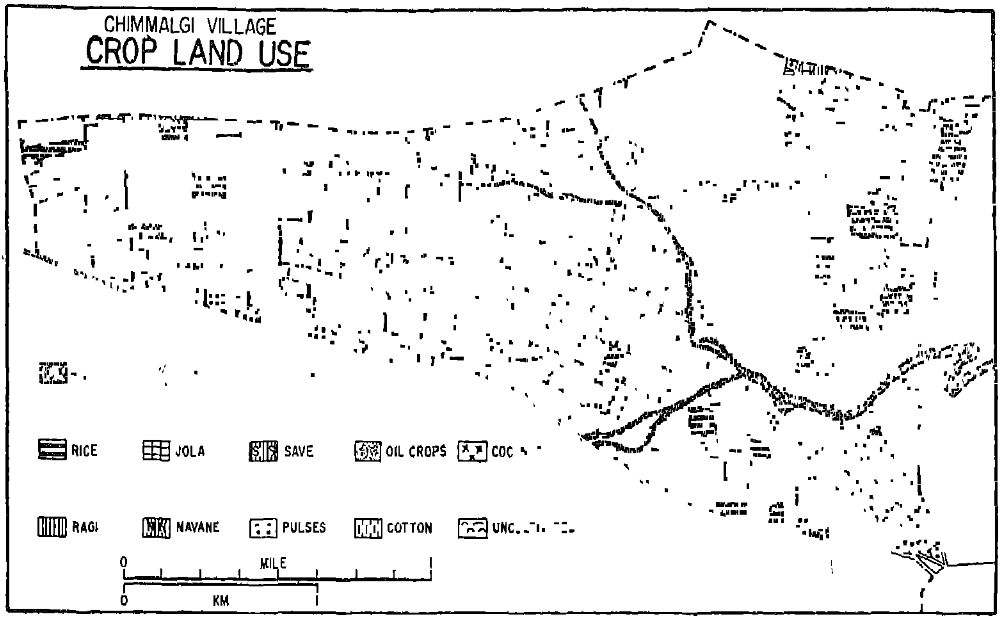


Fig. 56. Cadestral Map Showing Land Use
Source : Learmonth A.T.A. — Sample Villages in Mysore State.

The farmer is the person who takes decisions regarding the crop to be grown and the intensity of land use with irrigation and other inputs to raise the productivity of the land. Fill up the necessary information in a schedule as given in Table 1.

For the purposes of compiling the information you may have to form different groups of students say, two or three, and allocate the area to be covered by each group. This will enable you to cover a larger area in a short time.

The next stage of the work involves proper tabulation of the data from all the groups of students and to prepare a map of land use, using colours or line-shadings for different crops. Irrigated and unirrigated crops should be distinguished on the map by appropriate colours or by a combination of colour and line-shading. Another map may be prepared to show the soil types. Having completed the mapping, interpret the patterns of land use and its variations, taking note of the differences in soil types and intensity of cultivation by irrigation. Superimpose the maps of land use and soil types to prepare a composite map that would help you to analyse the relationship between the two. The data should be aggregated crop wise, distinguishing the irrigated and unirrigated areas for the whole area covered by the field work.

Analysis of the maps and tables is then presented as the final report of the field work, enclosing the maps and tables in appropriate sections of the report.

Catchment Area of a School

The objective of this study is to analyse the pattern of movement of school children from their residence to the school and to identify the catchment area of the school based on the intensity of movement.

A student of geography is not always aware of the fact that the site and broader regional situation of a school provide an opportunity to conduct a geographical investigation. The school, as in the case of a town or an industry, has a catchment area from which the students commute daily. The catchment area can also be termed as the sphere of influence of the school.

TABLE 1

Schedule for the Compilation of Land Use Data by Enquiring Farmers

Sl No.	Field No	Name of the farmer	Area of the field in hectares	Type of soil (red, black, loamy, etc)	Crops grown[1]					Irrigation[2]		
					Kharif		Rabi		Inter-season	Kharif	Rabi	Inter-season
					Rice	Jowar	Wheat	Cotton	Chillies			
1												
2												
3												
*												
*												
*												
*												
*												
*												

[1] Tabulate the crop actually grown

[2] Ask the farmer about the number of times he irrigates the land in a given time, and also about his sources of water for irrigation.

The students reach the school by various modes of transport depending upon the distance between the place of residence and the school, accessibility to the railway station, bus route, etc. They may also use a bicycle or school bus. Those who are economically well off might use private cars or scooters. A large number of students who stay near the school or those who are poor might walk to school. In conducting a field enquiry to demarcate the catchment area of a school, keep in view the following aspects of the study·

(i) Location of the school.
(ii) Location of students' residences.
(iii) Mode of transport.
(iv) Occupational and financial background of the family from which the students come.

Procedure for Conducting the Field Study

A map of the town or the village where the school is located is obtained and extra copies of the map are made, so as to carry out the survey by groups of students. In towns and cities, large-scale maps are generally available from the planning department, the municipality or the corporation, though you may have to trace your own copy from these. If the school is located at a small place, you will need a map of the *tahsil* (*anchal* or *thana* as the case may be) showing all the settlements and transport routes This is necessary because often a group of small villages or hamlets may depend for schooling facilities on a large village centrally located with reference to them.

From the school records collect the data and information in a tabular form as shown in Tables 2-4.

Having collected the data in tabular form as shown in Tables 2-4 the next step would be to prepare a flow map by drawing flow ribands or arrows with thickness proportional to the number of students. The technique of preparing flow maps is described in Chapter, 3 with illustrations. This will show the catchment area.

On a separate map prepare pie-graph map with radius of the circles proportional to the number of students coming from each

TABLE 2

Intensity and Pattern of Movement of Students from Residence to School

Address of the locality, ward, zone, etc. if it is a city	Total no of students residing	Mode of transport and no. of students					
		On foot	By bicycles	By passenger bus	By train	By private vehicle	By school bus

TABLE 3

Occupational Background

Ward/Zone or name of the place	No of students from different occupational background of the families			
	Agriculture	Business/ Trade	Industry	Others (specify the actual occupations)

TABLE 4

Number of Students from Different Income Groups

Zone/Ward or name of the place	No. of students from different income levels (Rs./month)				Remarks
	Less than 100	100-500	500-1000	Over 1000	

Note: It may be necessary for teachers to consolidate the data for this table from school records in such a way as to avoid embarrassing individual pupils with confidential information.

locality and with the sectors showing the proportion of students according to different occupation and income status

On the basis of a tour of different parts of the catchment area of the school, prepare a note describing the characteristics of each locality with special reference to the type of land use, i.e. residential (congested, open type), commercial, industrial, mixed, etc.

The final report should contain the maps and tables as mentioned above and an analysis of the patterns of movement and the extent and characteristics of the catchment area of the school.

Survey of a Market

Markets, whether in villages or urban centres, are principal places of sale and purchase of goods and, hence, a number of facilities and services come up spontaneously in them. Over the years, markets grow rapidly in population, facilities and economic activities. In relatively good agricultural areas, as in Punjab, Haryana and the Coimbatore plateau, market centres bustle with activities, often showing seasonal fluctuations in business and trade according to the rhythm of agricultural activities in the surrounding areas The study of a market essentially involves field observation and local enquiry with the help of a questionnaire

Objectives of the Survey

The survey of a market could have several objectives, depending upon the purpose of the study A market can be studied with a view to understanding and delineating its spheres of influence by enquiring into the types of commodities brought in or sold and the places which are involved in such transactions.

The second objective could be to study the number and types of shops and their arrangement or distribution in the market. There is a relationship between the population size of a place and its situation with reference to the surrounding area and the size and specialisation of market. In big cities, you often find that markets are distributed in different parts of the city and, often, each one specialises in the sale of certain commodities only, such as textiles, hardware and utensils, radios and other electronic goods, leather goods and furniture. You will also notice that the shops selling consumable goods like vegetables, and services like restaurants and barber shops are often scattered all over the place unlike textile or utensil shops which are clustered in selected areas. You will also find that the shops differ in their layout depending upon the type of commodity sold.

Conducting the Survey

We shall now illustrate the various stages in the procedure for conducting a survey of markets with the objective of analysing the distribution and pattern of association among the different types of shops that are located in a market.

A preliminary study has to be made in choosing a market, keeping in view its importance and distance from the school and accessibility. Once the selection of the market is made, a study is carried out with the help of the available reports, data and maps of the characteristics of the place, such as population, total area, important market areas within the place if the marketing facility occurs in more than one locality. District Census Handbooks provide information on the population size, facilities available, and occupations of the people Next step is to procure a map of the place If it is a city or a town you may get it from the town planning department or the municipality You may have to trace out a map from the original one in case a copy is not readily available. Alternatively, you may also prepare a rough map of the market before you undertake the survey.

Divide the number of students into separate groups in order to carry out the survey in different parts of the market Later on the information and observations thus collected are pooled together. This is necessary, if the size of the market is large.

Prepare a code either by letters or numbers for various establishments, such as V for vegetables, G for grains, S for stationery and so on. Alternatively, choose 1, 2, 3, etc for different types of establishments.

Walk along the road and plot the shops on either side, noting the type of shop and the commodities sold. You may enquire from shop-owners the important items which they are selling.

Against each type of shop noted on the map, write down the details about the types of buildings, single storeyed or multi-storeyed, wooden cubicles, or open spaces, where the commodities are kept for sale. It might be necessary to walk around initially to make a list of the types of buildings, so as to make it easy for classification later on.

Prepare two maps in colour or with symbols and line-shadings, one showing the type of shops according to their location and the other showing the type of building or the structure in which a shop is functioning.

Tabulate the data by counting the number of shops from your map as shown in Table 5.

TABLE 5

Structure of the Market according to Types of Shops

Sl. No.	Types of shops	No. of shops	Types of commodities (specify)	Location of shops	Types of buildings
1.	Provision store				
2.	Bicycle sales and repairs				
3.	Utensils				
	Total				

Notes. In the case of location of shops, you may note down whether they are at the corners, central or peripheral to the main shopping area. The map would enable you to specifically state the location and you may check with your own observation while plotting on the map as you move along the road. Likewise, note the type of building in which the items for sale are kept as mentioned earlier.

Work out the percentage of each type of shop to the total number of shops covered by the survey. For example, if the total number of shops covered is 100 and 25 shops are selling vegetables, then we say that 25 per cent of the shops deal in vegetables. Tabulate the percentages as under to get an idea of the predominance of certain types of shops.

TABLE 6

Types of shops

Total no. of shops	Types of shops (percentage of total)			
	1	2	3	4

In order to examine the pattern of clustering of shops, you may note down the number of shops of each type which occurs contiguously or in rows and find out the percentage of such shops to the total number of shops of the same type. For example, out of 20 bicycle shops you might find 15 of them located close to each other. Find out the percentage (in this case it is 75 per cent) in order to compare among the different types of shops the extent of clustering. Likewise, you may also classify the shops according to the types of buildings and their locations

The final report of the work should contain two maps as mentioned above along with tables and other interpretations.

Survey of an Industry

The survey of a small-scale industry, i.e. a small factory or workshop, engaged in secondary manufacturing activity is described below.

1 *Objectives*

1.1 To provide some answer (subject to critical evaluation) to the following

1.2 Why is the unit located where it is? (This is a minor objective, since field enquiry often fails to reward the fundamental reasons for the location of a manufacturing unit—or, more important, for its survival. However, the reasons stated by the industrialist may be of great interest.)

1.3 What use is made of the following:

- (i) The land occupied by the unit?
- (ii) Local resources including other industries or similar resources from elsewhere?
- (iii) Local labour of different grades or imported labour?
- (iv) Local capital or imported?
- (v) Local markets including other industries or elsewhere

1.4 Does the unit generate mainly income (but little employment) or is it labour-intensive and so contributes substantially to the local employment market?

Note: These objectives will be only partially fulfilled by the survey of a single manufacturing unit by an individual student or by a class. Much more meaningful results could be obtained where a class studies and compares a number of such units.

2. *Choice of Unit*

If possible, choose a small independent factory or workshop rather than a large one in the private sector or the public sector; the smaller scale units lend themselves better to a few hours of enquiry by an individual student or a small group of students than do the larger national or multi-national organisations. Very small units such as a small one-room machine, one-member rice mill or oil mill, are usually too small for a study of this particular kind.

3. *Questionnaire and Processing*

The following questions should be asked of the proprietor, manager, public relations officer or other responsible person. In some cases you should include a map or sketch map as your answer. As a guide, each question includes in brackets some remarks on how you should process the answers; under some questions there are additional notes which may help you in difficult cases.

3.1 What do you manufacture?

Note: If the unit produces a wide range of diverse items, state the main categories with examples. For example, a unit might produce small electric motors for sewing machines, hand drills, and pumps; small irrigation pumps; motors and components for other firms; and small electric circuits for radio manufacturers.

(Include in report as text.)

3.2 Why in your view is the unit located where it is?

- (i) Access to land.
- (ii) Access to labour
- (iii) Access to capital.
- (iv) Access to market
- (v) Personal preference for residence of owner/entrepreneur.
- (vi) Other reasons

Note: Summarise the respondent's answer in a sentence or so, and include in report as text. *See* also 1.2 above.

3 3 Raw materials or components

- (i) What are the chief materials or components used?

Note: if these are very numerous, give groups and examples.

(Include in report as text.)

- (ii) Where do they come from?
  (Include in report a map with an explanatory comment.)
- (iii) How are they processed?

Note: Try to understand the technology of the industry as well as possible on a short visit; the technology often affects the use of resources including the use of land and of floor space.

(Include in report as text, possibly with flow diagram.)

3.4 Capital goods, machinery and the like

- (i) What are the chief items of capital goods,

machinery and the like ?
(Include in report as text, possibly with cross-reference to flow diagram of processes.)

(ii) What is the paid-up capital of the unit ?
(Include in report as text.)

3.5 Inputs and outputs

(i) What is the nature of inputs per annum (give main items) ?

(ii) And of outputs ?

[Include in report as text, possibly with flow diagram, which might be merged with that of 3.3 (iii) above.]

3.6 Labour

Please give numbers employed in the following categories and the home addresses of all or a stated sample (every fifth, tenth, fifteenth and so on) for each category. Include the information in report as diagram (numbers) and flow map with explanatory comments.

	Numbers	*Home addresses*
(i) Manual		
(ii) Semi-skilled		
(iii) Skilled		
(iv) Secretarial or Clerical		
(v) Managerial or Executive		

3.7 Markets

Where are your products chiefly sold ?

Note You may have to select three or four main markets or group the products with examples of markets for particular products.

(Include in report as map with explanatory comments.)

3.8 Local and wider linkages

(i) Does the unit draw semi-manufactured components from other manufacturers (a) locally and (b) elsewhere ? State main items and places involved.

(ii) Does the unit supply semi-manufactured components for other manufacturers (a) locally and (b) elsewhere ? State main items and places involved.

(Include in report as map, with explanatory comments.)

3.9 Sources of capital (long term capital and working capital)

What are the main sources of the following ?

	Partners/ shareholders	Bank, cooperatives, etc.
	(a) Local (b) Elsewhere	(a) Local (b) Elsewhere
Long-term capital		
Working capital		

3.10 Land use

(i) What is the land use of your whole block?

Note : Include access roads, car parks, outdoor storage of materials or products, space for gardens, recreation etc.

(ii) What is the use of your floor space ?

(Include in report as map or sketch maps, possibly linked with flow diagram of process.)

3.11 Power

What sources of power do you use ?

(i) Electricity

(ii) Diesel

(iii) Steam

(iv) Others

Note : Use horse power, hours per day, kilowatt hours or other appropriate units. (Include in report as text)

3.12 Water

(i) What is the source of water ?

(ii) How much (in m^3) ?

(iii) For what purpose ?

(iv) What is the degree of pollution through discharge of waste material ?

(Include in report as text unless it is a main item for your unit, justifying a map or flow-diagram.)

3.13 Transport

What are the chief forms of transport used for:

	Rail	Lorry	Tempo	Bullock cart	Human labour	Other
(i) Raw materials						
(ii) Finished products						

(Include in report as text or diagram with comments.)

3.14 Stability or Change

(i) Is the unit stable/growing/declining ?

(ii) Are the processes stable or changing (if changing state nature of change).

(Include in report as text.)

4. *Conclusion*

Finish your report with a short section attempting to answer the questions raised in Section 1 concerning objectives. Add any views you have found about the significance of the industry for the economy and society of the town and its environs, or in some cases for the region and the nation.

5. *Identification, Mapping and Analysis of Physical Features*

Field work for the study of physical features is important as it helps the student of geography to observe personally the various features of the physical landscape and to interpret the patterns through the processes that are at work. The variations in land forms at the local level are very important in assessing the quality of the land as it affects the land use pattern and agricultural productivity.

A principal objective of this study is to observe and prepare a map of the physical features of the area chosen for study and to interpret the land form, rocks and soil types and land use variations. For this purpose, an attempt is made in the cartography laboratory to study and interpret the broad features of land forms, drainage and land uses as are shown in the topographical maps of large scale that are available.

The next step is to proceed to the study area and locate convenient points or features which are easily identifiable. They may be a foothill, or a hillock or a water feature such as a tank or a *nullah*. As the field party moves, the characteristics on either side are noted in a field book and a rough map of distinct land form features is made by plotting the features on a sheet of paper. Samples of rocks, soils and vegetation may be recorded, taking specimen only when necessary for identification, and numbered appropriately, so that the physical features plotted on the rough map can be interpreted in terms of the characteristics of rock types, land forms, soils and land use. Here are some examples of this type of field work

Coastal Area—Starting from the shore-line we often find sandbars and lagoons (water features in between the sandbars) almost parallel to the shore-line. The old sand dunes and the new ones would markedly differ in terms of land use, in that, the former are often used for coconut gardens and house sites Depressions between old sand dunes are often used for the cultivation of paddy Likewise, there might be isolated hills overlooking the shore-line and one could look for wave-cut platforms You can discuss if these have been formed by erosion of the hillsides by waves during high tide At the mouth of the river, one finds waterlogged marshy lands. Salt-pans are typical in some areas. These are some aspects of the field study which are not often understood clearly when we see them on a two-dimensional topographical map.

Narrow Valleys and Hills—A cross-profile of land forms and land uses can be produced as a part of the field work. You will notice distinct belts or zones of land use as you move from the top of the hill to the valley floor. The valley floor (or sides) may be scarred by gully erosion in places. You might observe isolated hamlets at suitable sites, say, to obtain water, to avoid flooding, etc , while the main villages may occur as nucleated settlements near a stream, and where routes converge from upstream, downstream and side valleys. Variations in soils can be studied by close observation of the sides of a gully. Mark the different horizons of the soil, i.e. layers in the soil of different colour, texture, etc., and note their characteristics. The soil samples can be tested in the laboratory to classify them into soils of varied textures and chemical constituents.

Alluvial Plain—Such a plain of a river may appear to be a monotonous landscape without variety on a small-scale map, but it provides interesting features of land forms carved out by a river in its later stages i.e., before it meets the sea. The one-inch (or 1 : 50,000 revised series) topographical map of the Survey of India will provide you details of the land forms and drainage pattern. Choose a portion of the alluvial landscape and trace out the pattern of drainage and other water features. Of particular interest are the identification of abandoned courses of rivers, extensive gully erosion along the drainage channels, and the flood plain of the main river. Look for the meandering patterns of the rivers and the formation of ox-bow lakes—a typical feature of the river action in its lower courses. Analyse the variations in land uses such as marshes and swamps, rich agricultural lands, and interpret the patterns of distribution. Also, identify the tidal influence of the sea on the river in which case you will notice the occurrence of saline marshes which generally are uncultivable and the water is not suitable for irrigation. On the basis of these observations and mapping of land forms, drainage, soils and land use prepare a report as a part of the field study.

EXERCISES

1. Prepare a land use map of a village using the schedule for data collection as given in the text, adopted as necessary to suit local circumstances. Interpret the pattern of land use. Does land quality influence land use and cropping patterns ? If not, what other influences are at work ? Discuss your findings in about 300 words.
2. Delineate the catchment area of the school using the data on the number and pattern of movement of students to the school from their places of residence Interpret the pattern of movement and the extent of the catchment area in terms of the socio-economic background of the students.
3. Conduct a survey of an industry according to the procedure given in the text. Write a note on the factors that have influenced the location of the industry.
4. Conduct a survey of the market and describe the pattern of distribution and clustering of different shops in the market. What are the differences in the patterns of distribution ? Write in about 300 words the salient features of the market you have studied.
5. Prepare rough maps of the land forms and land use features of the area you have studied and explain the relationship between them Write your answer in about 300 words.

Chapter 7

QUANTITATIVE METHODS

THE SUBJECT matter of geography, like that of other social and natural sciences, has been undergoing changes during the last decade The traditionally held view that geography deals with description of the earth is a challenge faced by contemporary geographers. Advances in technology and scientific surveys have provided more accurate data and information about the various features of the geographical landscape; and this in turn has provided the geographer with an opportunity to search for explanations about the patterns of distribution of physical, economic and socio-cultural elements, and the relationship, if any, among them. Thus, starting from qualitative description, the study of geography now makes use of quantitative data in description, analysis and interpretation of the spatial patterns and variations of geographical elements.

Measurement of the association among different elements of the geographical landscape and differentiation of the spatial patterns would require the application of appropriate techniques. Geographers are familiar with techniques of mapping and tabular analysis of data. Even then the explanation of the patterns of distribution tends to be mere description of the features observed on a map. Where the explanation is provided, it is likely to be based on a subjective judgement. For example, given the maps of distribution of rainfall and proportion of area under rice to total cultivated area, you might be able to compare the patterns visually and say that the areas of rice cultivation occur in heavy rainfall zones of 200 cm and above per annum In such a situation, you may be interested in measuring the extent of association between the rice cultivation and rainfall by calculating the correlation value.

A large amount of statistical data are compiled by different departments of the Government. These data tell us about the area, production and yield of different crops, irrigation, energy resources, population and so on. These data are compiled on the basis of administrative units such as the village and then aggregated to the levels of a *tahsil* or *thana*, district, state and the nation. Geographers have the opportunity to make use of appropriate data for mapping Analysis of the patterns and variations is also supported by statistical Tables. You must remember that statistical data are in absolute numbers when they are compiled and hence this raw data have to be processed in the form of ratio or percentage, density, and so on. The data may also require tabulation by aggregating them into smaller groups. Then there is the problem of comparison of the distribution of the phenomena on a map as well as in the form of a Table by arranging the values in descending order. For this purpose, mean or the average, median and modal values should be calculated. Distribution of different elements on the surface of the earth suggests that there is some kind of a relationship among them Often, the interaction among different elements needs evaluation as a combined effect of a number of factors or variables. Such problems can be effectively handled by the application of quantitative techniques. Some of these techniques are explained in this chapter with the help of illustrations.

Data Tabulation

Any statistical analysis is mainly based on quantitative information on the particular phenomenon under consideration. The study of cropping pattern of an area, for example, requires figures of geographical area, cultivable area, irrigated area, and area under different crops. A study of urbanisation, similarly, may require figures of total population, urban population, population of migrants, and their occupation-wise break-up. It may also require the density of population, the wages of labourers, the transport availability, number of industrial units, and other related information.

These quantitative informations about any characteristic are known as data. Almost every government organisation has a section which collects data for appropriate unit areas, e.g. for States, districts, *tahsils*, and villages. These data are compiled and published periodically for general use These reports are the easiest sources of data and are recognised as secondary sources. Such major sources of data for Indian economy are census reports, statistical abstracts of each State, National Sample Survey reports and Agricultural Statistics. Data provided through secondary sources, may not often be adequate. In such cases, a researcher has to generate his own data through primary sources, i.e. surveying the concerned places and collecting the data by himself.

Data for large number of observations, either collected through primary or secondary sources, need to be presented in a systematic and manageable form. This is necessary because the raw data, i.e. data as compiled, fail to convey important characteristics of the subject under study. But when arranged in a systematic way; many of its underlying characteristics come to light.

The principal method of presenting data in a systematic form is through tabular representation. The purpose of a Table is to simplify the presentation and to make comparisons easy. Generally, this simplification results from a clear-cut and systematic arrangement which enables the reader to locate the information he desires easily and quickly. Comparison is made easy by bringing related items of information closer.

A Table with its title should be able to explain itself, though it may often be accompanied by a paragraph or two of explanation, focussing attention on important figures. The logical arrangement of items in the *stub* (the left-hand column and its heading) and *box head* (the headings of the other columns) makes a Table clear and easy to read.

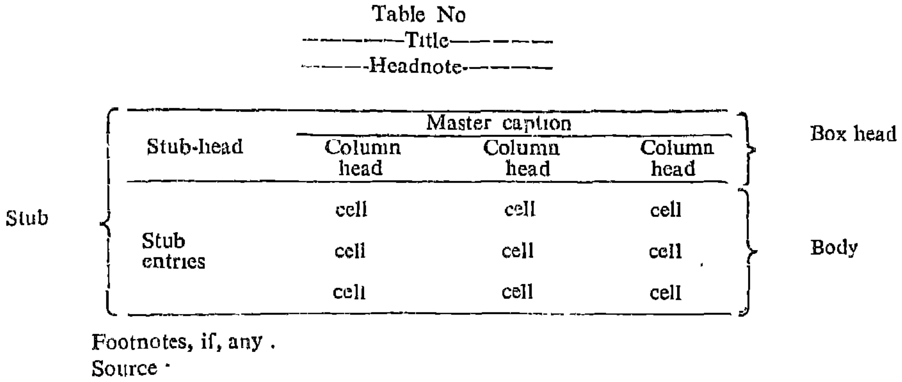
Types of Tables

There are two basic types of Tables · (i) the reference, general, repository or source Table, and (ii) the summary, text, or analytical Table.

As its names imply, a reference Table is a repository of information whose purpose is to present detailed statistical information A number of our Census Tables are reference Tables. These Tables are generally far larger than summary or analytical Tables and, hence, are usually carried to the appendices or as parts of separate volumes of information. Reference Tables, obviously, should aim at ease of reference On the other hand, the text or summary Table should emphasise items, relationships or significant comparisons.

Construction of Statistical Tables

The distinction between reference and summary Tables lies primarily in their use, and not in their construction. The basic structural features of both types of Tables are the same. The major functional parts of statistical Tables as shown in the following format are : (i) Table No., (ii) Title, (iii) Headnote, (iv) Stub, (v) Box-head, (vi) Body or field, (vii) Source note, and (viii) Footnotes



(i) *Table No.*—It permits one to cite a given Table readily. For ease of reference, Tables are numbered according to their order of appearance in a study or in a chapter

(ii) *Title*—In general, the title which appears at the top of the Table has to answer the questions, *what*, *where* and *when*, and, sometimes, *how* the data are classified, in that sequence. These are necessary in order to fully describe and delimit the contents and to guide the reader to the information he desires. A good title is compact, yet complete. If the complete title is unwieldy, it may be preceded by a short "catch" title.

(iii) *Headnote*—It appears near the title and provides additional information about the title which may have been excluded from the title, to make it compact (as in Table 1). Headnotes may be used to indicate the unit in which the data of the Table are expressed. Headnotes should be used only when actually needed. When they are used, they may be placed in brackets immediately following the title, or with or without brackets below the title. In Table 1, we have used supplementary information about the classification of the data of the Table "By Districts" as the headnote.

(iv) *Stub*—It contains : (a) *stub-head* and (b) *stub entries*. The stub-head describes the stub entries, whereas each stub entry labels the data found in its row of the table. In case of Table 1, the stub-head is "States/Districts" and stub entries are names of districts within a particular State, Tamil Nadu.

(v) *Box-head*—The caption or box-head lables the data found in the columns of the Table The caption consists of one or more column heads. Under a column head, there may be sub-heads (Refer Table 1).

(vi) *Body or Field*—This part contains the data presented in the Table. Each individual entry is presented in a cell, the basic unit of presentation in the Table. A given cell consists of the intersection of a given column and a given row. Hence, the meaning of the data in the cell is indicated by the combined labels of the intersecting column and row.

The format given above can be further condensed by clubbing the occupations into three broad categories, i.e. primary, secondary and tertiary activities. Such a condensation is given in Table 1.

(vii) *Footnote*—This is a statement which clarifies some specific entry or some specific part of the Table, or explains thereof, and is placed at the bottom of the Table. For example, the workers in primary, secondary and tertiary sectors require some explanation. An asterisk is, therefore, put at workers and in the footnote a break-

TABLE 1

Title

Workers and non-workers according to broad activities in Tamil Nadu, 1971

Head note

(By District)

Stub head — Box Head

State/District	Total population	Workers* Primary activity	Secondary activity	Tertiary activity	Non-workers
Tamil Nadu	41199168	9551801	2206572	2983594	26457201
1 Madras	2469449	10856	224154	461369	1173070
2 Chingleput	2907599	590616	179444	210695	1926844
3 North Arcot	3755797	947687	161748	223734	2422628
4 South Arcot	3617723	1020560	77945	156658	2362560
5 Dharampuri	1677775	519014	25467	66397	1066897
6 Salem	2992616	765423	239887	176969	1810337
7 Coimbatore	4373178	1045917	376232	364311	2586718
8 Nilgiris	494015	144729	20117	44967	284202
9 Madurai	3938197	986692	172260	294986	2484259
10 Tiruchirapalli	3848816	1019972	171104	234793	2422947
11 Thanjavur	3840732	941837	99069	242003	2557823
12 Ramanathapuram	2860207	674433	161141	184771	1839862
13 Tirunelveli	3200515	689517	238802	243197	2028999
14 Kanyakumari	1222549	212548	59202	78744	872055

Stub — Body

* Primary activity includes occupational categories I, II, III & IV
Secondary ,, ,, ,, ,, V & VI
Tertiary ,, ,, ,, ,, VII, VIII & IX

Source · Census of India, 1971, Vol. I, Part II-A (II), Union Primary Census Abstract, Registrar General of India, New Delhi, pp. 206-234.

up of the three sectors is provided.

(viii) *Source Note*—It indicates clearly from where the data were obtained, if they were not collected by the one presenting them. It is very essential to state the source, for this allows the reader to check the figures and possibly gather additional information. Further, it is also necessary as a part of professional ethics to give credit where it is due. For these reasons, the source note has to be unambiguous and complete as to title, edition, year of publication, page and also place of publication.

Frequency Distribution Table

The summary Table which condenses a large amount of information in a compact, systematic form is known as frequency distribution Table. This Table eliminates a considerable amount of complexity in making comparisons and, hence, has an important position in statistical analysis. In any frequency distribution Table, we divide the whole range of the values of a variable into some smaller groups, known as classes. The number of observations falling in each group, known as frequency, are recorded and are given in the Table along with the classes. The difference between upper and lower limits of a class is known as class interval. As an example of its construction, consider the workers as percentage to total population in 51 districts of Uttar Pradesh as given below for 1971.

District	Percentage of workers to total population
1. Uttar Kashi	32.16
2. Pithoragarh	45.15
3. Almorah	41.67
4. Naini Tal	39.63
5. Bijnor	34.37
6. Moradabad	28.91
7. Budaun	30.12
8. Rampur	30.83
9. Bareilly	30.68
10. Pilibhit	32.86
11. Shahjahanpur	35.06
12. Dehra Dun	35.25
13. Saharanpur	30.35
14. Muzaffarnagar	30.14
15. Meerut	27.79
16. Buland Shahar	27.37
17. Aligarh	28.18
18. Mathura	28.52
19. Agra	27.60
20. Etah	29.08
21. Mainpuri	27.82
22. Farukhabad	29.20
23. Etawah	27.24
24. Kanpur	30.38
25. Fatehpur	34.62
26. Allahabad	34.49
27. Jhansi	30.39
28. Jalaun	28.99
29. Hamirpur	33.23
30. Banda	36.37
31. Kheri	35.42
32. Sitapur	33.75
33. Hardoi	32.11
34. Unnao	31.47
35. Lucknow	30.69
36. Rae Bareli	32.62
37. Bahraich	36.83
38. Gonda	37.18
39. Bara Banki	36.04
40. Faizabad	34.07
41. Sultanpur	33.46
42. Partapgarh	34.99
43. Basti	35.65
44. Gorakhpur	34.53
45. Deoria	30.96
46. Azamgarh	30.06
47. Jaunpur	28.13
48. Balia	30.00
49. Gazipur	30.55
50. Varanasi	32.06
51. Mirzapur	37.60

As the highest value in the above data is 45.15 and the lowest 27.24, the range (i.e. the difference between the highest and the lowest values) is 45.15−27.24=17.91. If we make ten classes of equal interval, the class interval should be 17.91/10=1.791, which in round figure may be taken as 2. Thus, starting from 27 the classes we get and the number of observations falling in each class are given in the following Table. The process of tabulation becomes much easier if the values to be tabulated are read vertically and a bar is marked in a class where it falls. These bars are known as tally marks and are put in bundles of five to ease the counting.

Percentage of workers to total population	Tally marks	Frequency (No. of districts)
27—29	𝍸 𝍸	10
29—31	𝍸 𝍸 ||||	14
31—33	𝍸 |	6
33—35	𝍸 ||||	9
35—37	𝍸 ||	7
37–39	||	2
39–41	|	1
41—43	|	1
43—45		0
45–47	|	1
Total		51

TABLE 2

Distribution of the size of 100 families of a locality

Size of family (X)	Number of families (f)
1	4
2	12
3	26
4	20
5	17
6	15
7	6
Total	100

Before preparing a frequency distribution, the following points should be noted:

(i) The classes like 27-29, 29-31, 31-33, etc. mean above 27 but less than 29, above 29 but less than 31, above 31 but less than 33, and so on.

(ii) Number of classes should not be either very large or very small. A distribution with considerably smaller number of classes (say, two or three) will cause heavy loss of information. A distribution with too many classes (say, 50 or 60), on the other hand, may be inconvenient to handle. Though there is no fixed limit to the optimal number of classes, normally they should not be less than 8 or 9 and more than 20 or 25.

(iii) As far as possible, the class intervals should be kept equal.

An ungrouped or discontinuous frequency distribution is that where, instead of classes, the fixed values of the variable are given. An ungrouped frequency distribution may look like a distribution as given in Table 2.

Cumulative Frequency

Cumulative frequency is the total number of observations less than or equal to a given value of the different classes. It consists of two types, i.e. more than and less than types.

Consider the frequency distribution of the percentage of workers in 51 districts of Uttar Pradesh. The Table given below presents the cumulative frequencies of both the types described above.

The cumulative frequency as given in column (3), shows that there are 10 districts where the percentage of workers is less than 29. As there are 14 other districts in the second class where the percentage of workers is 29 and more but less than 31, the number of districts where the

Class of percentage workers to total population	Frequency	Cumulative Frequency Less than type	Cumulative Frequency More than type
(1)	(2)	(3)	(4)
27—29	10	10	51
29—31	14	24	41
31—33	6	30	27
33—35	9	39	21
35—37	7	46	12
37—39	2	48	5
39—41	1	49	3
41—43	1	50	2
43—45	0	50	1
45—47	1	51	1
Total	51		

percentage of workers is less than 31 is 10+14 =24. Similarly, the number of districts in which the percentage of workers is less than 33 is 30, and so on.

Take the values of column (4) from bottom. The frequency of last class is 1 and shows that there is only one district where the percentage of workers is 45 and more. There is no district where this percentage is between 43 and 45. So, this percentage more than 43 is still in only one district. The number of districts where the percentage is more than 41 is two, and there is only one district where the percentage is more than 43. Thus, total number of districts where percentage of workers is more than 41 is two. Similarly, there are three districts where percentage is more than 39, five districts where the percentage is more than 37 and so on.

Important Notations

Variables—The characteristics whose values vary from one observation to another observation are known as variables. For example, rainfall is a variable as it varies from one point to another over space as well as over time. Other examples of the variables may be district-wise density of population, area of crop sown, urban population, per acre consumption of fertilisers, percentage of irrigated area to total cropped area, number of towns, number of tubewells, number of primary schools, etc.

For the sake of compactness, the different variables are mathematically represented by some symbols. Generally, the symbols used to denote the variables are the alphabets U, V, X, Y and Z.

Subscript of the Variables—After denoting the different variables by X, Y, Z, etc. we may distinguish two variables, but we cannot differentiate between the different values of the same variables. The difficulty is easily removed by attaching a small number with a variable, which corresponds to the serial number of the value. For example, if X denotes the per capita income of n districts, $X_1, X_2, X_3 \ldots\ldots\ldots\ldots X_n$ will mean per capita income of 1st, 2nd, 3rd and so on up to the nth district in the list.

Summation Sign—If we want to represent the sum of the annual incomes (denoted by X) of 100 persons, we would have to write all the Xs right from X_1 to X_{100} and put a plus sign in between each of them. Such lengthy expressions can be conveniently written with the help of the summation sign *sigma* (Σ). Using the *sigma* sign it can be written as:

$$\sum_{i=1}^{100} X_i$$

Which means all the values from X_1 to X_{100} have been added. Thus

$$\sum_{i=1}^{100} X_i = X_1 + X_2 + X_3 \ldots\ldots\ldots + X_{100}$$

The summation sign can operate over algebraic expressions also, like

$$\sum_{i=1}^{3} (X_i + Y_i) = (X_1 + Y_1) + (X_2 + Y_2) + (X_3 + Y_3)$$

$$\sum_{i=1}^{50} Y_i X_i = Y_1 X_1 + Y_2 X_2 + Y_3 X_3 \ldots\ldots + Y_{50} X_{50}$$

$$\sum_{i=1}^{4} CX_i = CX_1 + CX_2 + CX_3 + CX_4 = C(X_1 + X_2 + X_3 + X_4) = C \sum_{i=1}^{4} X_i$$

$$\sum_{i=1}^{n} C = C + C + C + \ldots \ldots C \text{ (n times)} = nC$$

Measures of Central Tendency

We have already discussed the problem of condensation and presentation of data in the previous section. Very often it becomes necessary to obtain a single representative value for the entire data. This representative value enables one to get an overall idea about a particular distribution. Moreover, it enables one to make comparisons between different distributions. For example, it is often said that Americans are richer than Indians.

As we know, there are about 240 million Americans and 610 million Indians. Although most of the Americans may be richer than most of the Indians, there are a few Indians who may be richer than many other Americans How then, do we compare the richness of one country with another? In real life, we keep on making such comparisons all the time. For example, we say that the people of Rajasthan are taller than those of Nepal or of Assam, the yeild of wheat in Punjab is higher than that in any other State in India, and so on. In all these cases, the statements are not based on comparisons of individual incomes in America and India, heights of Rajasthanis and Nepalese or Assamese, yield of every plot in Punjab and other states, but on some measures, which summarise these individual values. The summary values that are representative of the various distributions are known as "measures of central tendency". The commonly used measures of central tendency are :

(i) Arithmetic mean or the average.
(ii) Median.
(iii) Mode.

Arithmetic Mean

The most frequently used measure of central tendency is the arithmetic mean or the average. The arithmetic mean is simply the sum of all the individual values in a distribution divided by their number.

Supposing the monthly consumption expenditure of 5 agricultural labour families in a village is Rs 100. Rs. 80, Rs. 120, Rs. 90 and Rs. 60. The mean consumption expenditure of these families is

$$\frac{100+80+120+90+60}{5} = \text{Rs. } 90.$$

Supposing there are 'n' agricultural labour families in a region. If X_1, X_2, $X_3 \dots \dots X_n$ stand for the consumption expenditure of the 1st, the 2nd, the 3rd and the nth agricultural labour family respectively, the arithmetic mean would be :

$$\bar{X} = \frac{X_1+X_2+X_3 \dots \dots + X_n}{n}$$

$$= \frac{\Sigma X}{n} \text{ when } \Sigma X = X_1 + X_2 \dots\dots + X_n$$

In the foregoing example, we had consumption data of each the agricultural labour family. If the number of such families is not very large the arithmetic mean can be easily computed in the manner indicated above

The computation of the arithmetic mean for small ungrouped data does not pose many problems. However, very often, the data are made available not in an ungrouped form but in the form of frequency distribution. The arithmetic mean of a frequency distribution is given by

$$\bar{X} = \frac{f_1 X_1 + f_2 X_2 \dots\dots + f_n X_n}{f_1 + f_2 \dots\dots + f_n}$$

$$= \frac{\Sigma f X}{n}$$

where X_1, $X_2 \dots \dots X_n$ are the middle values of the 1st, 2nd, .and nth class, f_1, f_2 . .....f_n are the frequencies of 1st, 2nd..... and nth class.

Example 1 (Ungrouped Data)

The record of rainfall in a month at 10 stations of a district is given below. Compute the average rainfall of the month in the district.

Station	A	B	C	D	E	F	G	H	I	J
Rainfall in mm	10.2	15.3	18.9	9.9	12.5	11.1	10.5	10.4	10.5	10.7

Solution

$$\text{A.M.} = \frac{10.2+15.3+18.9+9.9+12.5+11.1+10.5+10.4+10.5+10.7}{10}$$

$$= \frac{120.0}{10} = 12.00 \text{ mm}$$

Example 2 (Grouped Data)

Compute the arithmetic mean from the rainfall data given in the Table below.

Classes (Rainfall in mm)	No of day (f)	Mid-value of the classes (X)	f (X)
30—35	5	32.5	162 5
35—40	6	37 5	225 0
40—45	11	42 5	467 5
45—50	18	47.5	855 0
50—55	19	52 5	997 5
55—60	15	57 5	862.5
60—65	13	62 5	812.5
65—70	1	67.5	67 5
70—75	2	72.5	145.0

From the above $n = \Sigma f = 90$ and $\Sigma f(X) = 4595$

$$\therefore \bar{X} = \frac{\Sigma fX}{n} = \frac{4595\ 0}{90} = 51.055 \text{ mm}$$

Short-cut Method—It becomes convenient to use a short-cut method where the data are very large, in a frequency Table of equal class interval. The formula for calculating the mean by this method is :

$$\bar{X} = a + \frac{fu}{f} \times h$$

where "a" stands for the assumed mean; and "u" stands for the deviation of each mid-value from the assumed mean, divided by class interval "h" i.e. $u = \frac{X-a}{h}$

While the assumed mean may be any arbitrary value, we usually choose one of the mid-values in the middle of the series, preferably one with the highest frequency. The choice of such a mid-value as the assumed mean reduces computation work.

Let us now calculate the mean rainfall by the short-cut method from the data given in the previous example. Taking 52.5 as the assumed mean, the mid-value with the highest frequency, we proceed as below :

Classes (Rainfall in mm)	Mid-values (X)	$u = \frac{X-52\ 5}{5}$	No of days (f)	fu
30—35	32.5	— 4	5	—20
35—40	37.5	— 3	6	—18
40—45	42.5	— 2	11	—22
45—50	47 5	— 1	18	—18
50—55	52 5	0	19	0
55—60	57.5	+ 1	15	15
60—65	62 5	+ 2	13	26
65—70	67.5	+ 3	1	3
70—75	72 5	+ 4	2	8

From the above : $\Sigma fu = -26$ and $\Sigma f = 9$

$$\text{Now} \quad \bar{X} = a + \frac{\Sigma fu}{\Sigma f} \times h$$

$$= 52.5 + \left(\frac{-26}{90} \times 5\right)$$

$$= 52.5 - 1.444$$

$$= 51.056 \text{ mm.}$$

Characteristics of Arithmetic Mean

Arithmetic mean is the most frequently used measure of central tendency because: (i) it is simple to compute and easy to understand, (ii) it takes into account all the values of the variable, and (iii) it is least affected by fluctuations of sampling. However, arithmetic mean has certain limitations which are described below.

Arithmetic mean is affected by extreme values. Any large value on either end can push it up or down. In real life problems, the lowest values are generally not below 0; therefore, arithmetic mean has a built-in upward bias. One single large value with several small values will push up the arithmetic mean considerably. A single small value with several large values, however, may not pull it down to the same extent.

We may, sometimes, have frequency distributions with open-end classes. It is not possible to exactly locate the mid-values of these open-end classes ("Less than... ....." at one end of a frequency distribution and/or ".. ...and more" at the other end) and, therefore, it is not possible to accurately determine $\bar{X}$. For example, if we get a frequency distribution with the first class as "less than 200", and the last group as "2000 and above", we would not know the exact mid-value of the lowest and the highest classes Hence, it would not be possible to compute the arithmetic mean accurately.

Median

Arithmetic mean, as we have already noted, is an average of values in a given series and is, therefore, affected by extreme values. The effect of extreme values can be avoided if, instead, we take a measure of central position in a given series. This position measure is called the median. The median is that value which divides a series into two equal parts, so that half or nearly half the values lie below it and the other half or nearly half above it.

Consider the income of seven persons working in a shop. Six of them are workers whose monthly salaries are Rs. 120, 130, 150, 100, 170 and 180. The seventh person is the owner of the shop and his monthly income comes to Rs. 3000. The mean of the income of these seven persons is (120+130+150+100+170+180+3000)÷7=Rs. 550 per month. In this case, because of a single extreme value the mean has been pushed up and is a highly misleading and inappropriate measure of central tendency. The income of most of the workers lies far below the average. In such cases, an appropriate measure of central tendency would be the median.

To find the median, we have first to arrange the data in ascending or descending order. Arranging the above data in an ascending order, we get : 100, 120, 130, 150, 170, 180, 3000. Since there are seven observations, the fourth observation occupies the central (or the middle) position. The value of the fourth position is Rs. 150, which is the median. Three observations, namely 100, 120, 130 lie below it and the other three, namely, 170, 180 and 3000 lie above it. Obviously, this value is a much better representative of the central tendency of the data than the mean. In our example, the number of observations is odd and hence we can locate the middle value as an actual value. If, however, the number of observations is even, there will be two observations falling in the middle and their mean will be taken as the median, as explained in the following example.

Example

The monthly incomes (in Rs.) of twelve households in a locality are : 140, 150, 130, 135, 170, 190, 500, 210, 205, 195, 290 and 200.

Arranging these incomes in an ascending order, we get : 130, 135, 140, 150, 170, 190, 195, 200, 205, 210, 290 and 500.

There are two middle positions, namely, sixth and seventh in the above data with values 190 and 195 respectively. The median, therefore, is the mean of these two values :

$$\text{Median} = \text{Rs. } \frac{190 + 195}{2} = \text{Rs. } 192.5$$

Median from Grouped Data—In this case, the median falls in the class in which the middle position, i.e. the N/2th item lies. We have, therefore, to locate this class, viz. the median class. Since we do not know the distribution of the observations in a class, we have to assume that the observations in the class are evenly distributed. The median can now be obtained by interpolation as follows :

$$\text{Median} = L_1 + \left(\frac{N/2 - C}{f}\right) h$$

where L_1 is the lower limit of the median class, C is the cumulative frequency of the class preceding the median class, f is the frequency of the median class, and h is the magnitude of the median class interval.

Example

The number of households with the size of their land holdings is given below. Let us calculate the value of the median land holding.

We may observe from col. 3 that the first

Size in hectares	No. of households (f)	Cumulative frequency
0—1	550	550
1—3	600	1150
3—5	400	1550
5—10	250	1800
10—20	110	1910
20—50	85	1995
50 and above	5	2000
Total	2000	

550 holdings in ascending order lie in the size-group 0—1 hectare; the next 600 holdings, from 551st to 1150th, lie in the size-group 1-3 hectares; the next 400 holdings, from 1151st to 1550th, are in the size-group 3-5 hectares; and so on. The cumulative frequency given in col. 3, therefore, enables us to locate the median class. In our example, $N/2=2000/2=1000$. Therefore, the 1000th household lies in the size-class 1—3 hectare. Hence, $L_1=1$, $h=3-1=2$, $f=600$, and $C=550$.

$$\begin{aligned}\therefore \text{Median} &= L_1+\left(\frac{N/2-C}{f}\right)\times h\\ &= 1+\left(\frac{1000-550}{600}\right)\times 2\\ &= 1+1.5\\ &= 2.5 \text{ hectares}\end{aligned}$$

This means that in our distribution of land holdings by size about 1000 holdings, i.e. 50 per cent, are below 2.5 hectares and the rest above it.

Let us attempt to compute the arithmetic mean of this series, even though it is an inappropriate average. We immediately run into the problem of an open-end class, "the 50 and above" hectares holding class. If we do not have access to the raw data, from which the frequency distribution has been formed, we shall have to set an arbitrary upper limit to this class. Obviously, the higher this upper limit, the higher the value of the mean will be. We assume here an upper class limit of 100 hectares; normally, the magnitude of this class interval will be greater than 30, the size of the previous class The mean size of the holding, $\bar{X}=4.975$ hectares, is almost twice the median of 2.5 hectares. Since the distribution is skewed to the right, the mean has been pulled towards the large (extreme) values.

However, unlike the mean, the median as a measure of position, is not affected by all the values. It would be affected only by the values of the central items in a series. It is, therefore, found to be a useful measure of central tendency for non-symmetrical distributions such as distributions of land holdings, income and wealth, urban settlements, and so on.

The median is also not affected by unequal class intervals or the existence of open-end classes as may be seen in our example of distribution of land holdings by size groups. Similarly, even if a few items at the beginning or at the end in an array are missing, but we know the number of such missing items, we can calculate the median. The median, however, cannot be calculated without the data being put in the form of an array in an ascending or a descending order. This can be quite tedious and time consuming, if data are large. Similarly, in case of irregular data where gaps occur near the median, it is not a particularly good measure of central tendency. This is because the value of the median will be erratic if one or two items are added or substracted from the series.

Partition Values

We have already noted that the median is a value which divides the series into two nearly equal parts. In order to know more about the distribution, we may like to locate the values which divide the observations into four, ten, hundred, or 'n' equal parts.

Quartiles

The values which divide a series into 4 equal parts are known as quartiles. For any distribution, there will be 3 quartiles, denoted as Q_1,

Q_2 and Q_3. Q_1, the first or lower quartile, divides the series in such a way that 1/4th of total observations fall below it and 3/4th above it. Q_2, the second or middle quartile, has 2/4th (i.e., ½) of the observations below it and 2/4th (i.e., ½) above it. Students will note that Q_2 is the same as the median. 1/4th of the observations will be between Q_1 and Q_2 (or median) as also between Q_2 (median) and Q_3. Similarly, Q_3, the third or the upper quartile, has 3/4th of the values below it and 1/4th above it.

The method of locating the quartiles is similar to that used for finding the median. We first locate the classes where the quartiles lie. Thus, for Q_1, we have to identify the class where the N/4th observation lies. Similarly, for Q_3, we locate the class containing the 3N/4th observation. After locating these classes, the values of Q_1 and Q_3 can be interpolated as follows:

$$Q_1 = L_1 + \left(\frac{N/4 - C}{f}\right) \times h$$

where L_1 = the lower limit of the lower quartile class, f = frequency of the lower quartile class, h = the magnitude of the lower quartile class interval, and C = cumulative frequency of the class preceding the lower quartile class:

$$\text{and } Q_3 = L_1 + \left(\frac{3N/4 - C}{f}\right) \times h$$

where L_1 = the lower limit of the upper quartile class, f = frequency of the upper quartile class, h = the magnitude of the upper quartile class interval, and C = the cumulative frequency of the class preceding the upper quartile class.

Let us now compute Q_1 and Q_3 for our distribution of land holdings by size given in the previous Table, showing size distribution of land holdings.

N/4 = 2000/4 = 500.

The 500th holding lies in the class, 0—1 hectare, that is our first land holding class. Hence, to locate Q_1, we have:

$L_1 = 0$

$f = 550$

$1-0 = 1$

$C = 0$ (Since we do not have a class preceding the lower-quartile class, the cumulative frequency of this non-existent class can be safely presumed to be zero).

$$\therefore Q_1 = L_1 + \left(\frac{N/4 - C}{f}\right) \times h$$

$$= 0 + \frac{500 - 0}{550} \times 1$$

$$= \frac{500}{550} = \frac{10}{11} = 0.91 \text{ hectares.}$$

This implies that 500 land holdings, i.e. 25 per cent of the total, are below 0.91 hectares and 1500, i.e. 75 per cent, above it. It also implies that another 500, i.e. 25 per cent of the land holdings, lie between 0.91 hectares (= Q_1) and 2.5 hectares (= Q_2 = Median).

Similarly, we can locate the Q_3, i.e. upper quartile class, by finding out in which class the 3N/4 = 3/4×2000=1500th land holding lies.

From col. 3, we observe that the 1500th holding lies in the size-class 3-5 hectares. Hence, for computing the upper quartile

$L_1 = 3$

$f = 400$

$h = 5-3 = 2$, and

$C = 1150$.

$$Q_3 = L_1 + \left(\frac{3N/4 - C}{f}\right) \times h$$

$$= 3 + \frac{1500-1150}{400} \times 2 = 3 + \frac{7}{4}$$

$$= 4.75 \text{ hectares}$$

Our upper quartile, Q_3 = 4 75 hectares, indicates that approximately 75 per cent of all land holdings lie below this size and 25 per cent above it.

Deciles

The values which divide a distribution into 10 equal parts are known as deciles. Obviously, there are nine deciles, D_1, D_2, D_3......D_9 and D_5, the 5th decile, is the same as Q_2 or the median. The value of any decile, say D_j, the jth decile will be found, as in case of the median and quartiles, as follows :

$$D_j = L_1 + \left(\frac{jN/10 - C}{f}\right) h$$

where L_1 = the lower limit of the jth decile class, f = the frequency of the jth decile class, h = the magnitude of the jth decile class interval, and C = the cumulative frequency of the class preceding the jth decile class.

Let us compute D_3, the 3rd decile and D_9, the ninth decile, for our distribution of land-holdings.

$$D_3 = L_1 + \left(\frac{3N/10 - C}{f}\right) h$$

$$\text{and } D_9 = L_1 + \left(\frac{9N/10 - C}{f}\right) h$$

$$\text{Now,} \quad 3N/10 = \frac{3 \text{ x } 2000}{10} = 600$$

$$\text{and} \quad 9N/10 = \frac{9 \times 2000}{10} = 1800$$

The 600th land holding lies in the size-group, 1-3 hectares and hence : $L_1 = 1, f = 600$, $h = 2$, and $C = 550$.

$$\therefore D_3 = 1 + \frac{600 - 550}{600} \times 2$$

$$= 1.17 \text{ hectares}$$

The 1800th land holding lies in the size-class, 5-10 hectares Actually it is the last, i.e. the topmost holding of this class.

Hence : $L_1 = 5, f = 250, h = 5$, and $C = 1550$.

$$\therefore D_9 = 5 + \frac{1800 - 1550}{250} \times 5$$

$$= 10 \text{ hectares.}$$

The above shows that 3/10 or 30 per cent holdings lie below 1.17 hectares and 7/10 or 70 per cent above it. Similarly, with D_9 at near 10 hectares, 9/10 or 90 per cent holdings are below 10 hectares and only 1/10 or 10 per cent above it.

Percentiles

The values which divide a series into 100 equal parts are known as percentiles, so that there are 99 percentiles, $P_1, P_2, \ldots\ldots P_{99}$. The jth percentage is given by

$$P_j = L_1 + \left(\frac{jN / 100 - C}{f}\right) h$$

where L_1 = the lower limit of the jth percentile class, f = the frequency of this class, h = the magnitude of the jth percentile class interval, and C = the cumulative frequency of the class preceding the jth percentile class.

Let us calculate P_{65}, the 65th percentile.

$$\text{Now, } P_{65} = L_1 + \left(\frac{65N/100 - C}{f}\right) h$$

We have first to locate the class containing P_{65} i e. where 65N/100th item lies.

$$65N/100 = 65/100 \times 2000 = 1300$$

The 1300th land holding lies in the size-group, 3—5 hectares, so that, $L_1 = 3$, $f = 400$, $h = 2$, and $C = 1150$.

$$P_{65} = 3 + \left(\frac{1300 - 1150}{400}\right) \times 2$$

$$= 3.75 \text{ hectares.}$$

This means that 65 per cent of the holdings are below 3.75 hectares and 35 per cent above it. We can similarly find the value of any other percentile. For some purposes, one may like to study a distribution by dividing it into 5 equal parts through quintiles or 8 equal parts through octiles, or any other number (n) of equal parts The procedure for computing these will be the same as for other partition or position values.

Partition or position values help us to study different parts of a distribution and thus know more about its structure. The practical utility of this concept in geography will become clear from the following examples.

Example

The districtwise percentage of literates to total population in Madhya Pradesh is given below for 1971. Divide the districts into four groups of low, medium, moderate and high literacy.

Sl. No.	District	Literates, %
1	Morena	19.77
2	Bhind	23.94
3	Gwalior	33,94
4	Datia	21.77
5	Shivpuri	16,87

6	Guna	17.47
7	Tikamgarh	13.93
8	Chattarpur	15.16
9	Panna	14 83
10	Satna	20 68
11	Rewa	19 60
12	Shahdol	14.65
13	Sidhi	10 74
14	Mandsor	27 63
15	Ratlam	25.63
16	Ujjain	28 56
17	Jhabua	8 21
18	Dhar	16.76
19	Indore	44 35
20	Dewas	21.55
21	Khargaon	18 78
22	Khandwa	28 02
23	Shajapur	18.96
24	Raigarh	14 37
25	Vidisha	18.33
26	Sehore	28.57
27	Raisen	18.38
28	Hoshangabad	19 43
29	Betul	22.42
30	Sagar	27.62
31	Damoh	23.28
32	Jabalpur	34 26
33	Narsimhapur	29.24
34	Mandla	18 31
35	Chhindwara	21 91
36	Seoni	21.31
37	Balaghat	25.13
38	Surguja	12.36
39	Bilaspur	22 79
40	Raigarh	19.92
41	Durg	24 75
42	Raipur	23 60
43	Bastar	9 64

Source · Provisional Population Total. Census of India 1971.

Arranging these 43 values in descending order, we get :

8.21 9.64 10.74 12 36 13 93 14.37 14 65 14 83 15.16
16.76 16.87 17 47 18 31 18 33 18 38 18 78 18 96 19.60
19.77 19.92 20 68 21.31 21.55 21.77 21.91 22.42 22.79
23.28 23.60 23.94 24 75 25.13 25.63 27 62 27.63 28.02
28.56 28 57 29 24 29 43 33.99 34.26 44.35

We get the middle value as 21.31 (median) or Q_2. The middle value of the first half values is found to be 16.87 (Q_1), and that of the second half values to be 25.63 (Q_3).

Thus we see that there are 10 values below 16.87 (Q_1), eleven, values from 16.87 to below 21.31 (Q_2), eleven values from 21.31 to below 25.63 (Q_3), and also eleven values of 25.63 and above.

Once the values of quartiles are worked out they can be rounded for simplicity of presentation. Rounding is done in such a way that it does not alter the grouping very much. The above grouping, for example, in a rounded form would be :

Name of the group	Range of percentage	No. of districts
Low literacy	Less than 17	11
Medium literacy	17 to less than 20	9
Moderate literacy	20 to less than 25	11
High literacy	25 and above	12

The districts falling in each group are given below.

Group 1 (Low Literacy)—Shivpuri, Tikamgarh, Chhatarpur, Panna, Shahdol, Sidhi, Jhabua, Dhar, Raigarh and Bastar.

Group 2 (Medium Literacy)—Morena, Guna, Rewa, Khargaon, Shajapur, Vidisha, Raisen, Mandla, and Raigarh.

Group 3 (Moderate Literacy)—Bhind, Datia, Satna, Dewas, Betul, Damoh, Chhindwara. Seoni, Bilaspur, Durg, and Raipur.

Group 4 (High Literacy)—Gwalior, Mandsor, Ratlam, Ujjain, Indore, Khandwa, Sehore, Hoshangabad, Sagar, Jabalpur, Narsimhapur, and Balaghat.

The spatial pattern of distribution of literacy is shown in Fig. 57.

Putting the values in order becomes difficult if the number of observations are very large. In such cases, first the values are arranged in a tabular form and then the values of Q_1, Q_2 and Q_3 are interpolated in the manner explained earlier.

Example

The distribution of the rural settlements of Punjab according to their size is given below

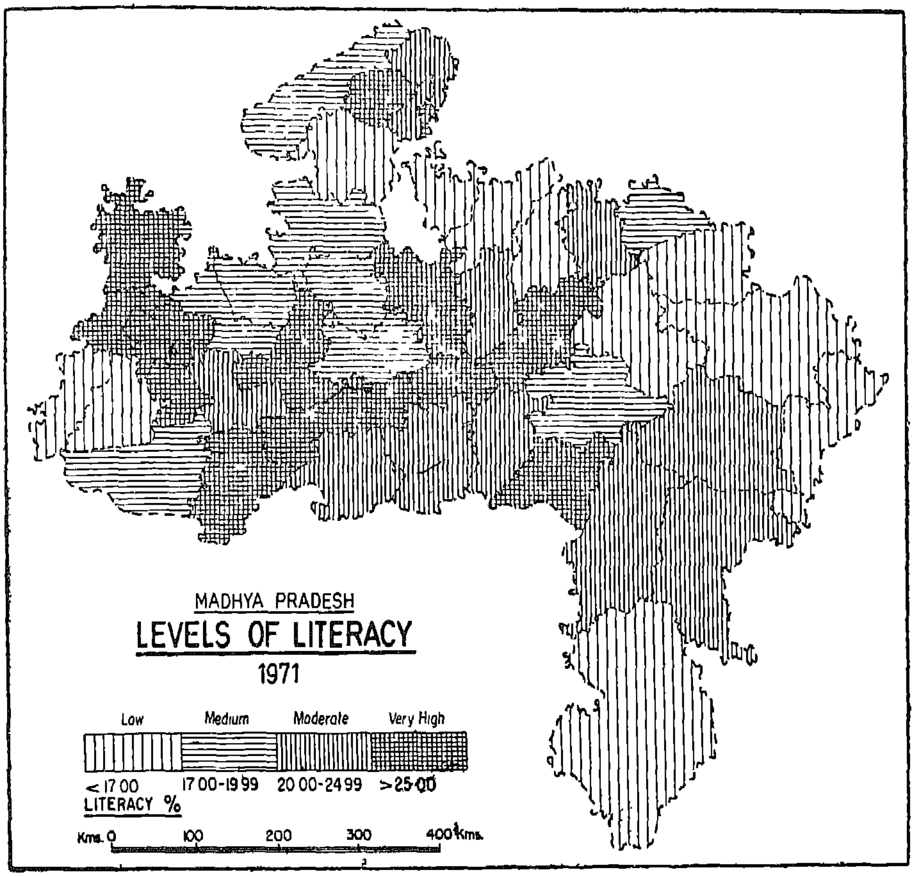


Fig 57 Selection of Class Intervals and Mapping (Choropleth)

for 1971. Find out the ranges to divide the villages in four groups having almost equal number of villages. Also, find out the most representative size of the villages in Punjab.

Class (Population)	Frequency (No. of villages)	Cumulative frequency
Less than 200	1887	1887
200 — 500	3311	5198
500 — 1000	3577	8775
1000 — 2000	2392	11167
2000 — 5000	940	12107
5000 — 10000	79	12186
10000 and above	2	12188
	12188	

Source : Census of India 1971.

For the first quartile, Q_1, we have to get first $\frac{N}{4}$, i.e. $\frac{12188}{4} = 3047$, which falls in the class 200—500, and so : $L = 200$, $C = 1887$, $f = 3311$, and $h = 500 - 200 = 300$.

$$\therefore Q_1 = 200 + \frac{3047 - 1887}{3311} \times 300$$

$$= 200 + \frac{1160 \times 300}{3311} = 200 + 105.104$$

$$= 305.104 \text{ or } 305 \text{ persons.}$$

For Q_2, the median, we have to work out $\frac{N}{2}$, i.e. $\frac{12188}{2} = 6094$, which falls in the class 500—1000, and so : $L = 500$, $C = 5198$, $f = 3577$, and $h = 1000 - 500 = 500$.

$$\therefore Q_2 = 500 + \frac{6094 - 5198}{3577} \times 500$$

$$= 500 + \frac{896 \times 500}{3577} = 500 + 125.244$$

$$= 625\ 244 \text{ or } 625 \text{ persons}$$

For Q_3 we have to work out $\frac{3N}{4}$, i.e. $\frac{3 \times 12188}{4} = 9131$, which falls in the class 1000—2000, and so · L = 1000, C = 8775, f = 2392. and h = 2000 — 1000= 1000.

$$\therefore Q_3 = 1000 + \frac{9131 - 8775}{2392} \times 1000.$$

$$= 1000 + \frac{356}{2392} \times 1000 = 1000 + 48\ 83$$

$$= 1048.83 \text{ or } 1049 \text{ persons.}$$

Thus the villages can be divided according to their sizes into following four quartiles for purposes of classification as done in the previous example.

Size	Population
Low	less than 300
Medium	300 to 625
Moderately high	625 to 1000
Very high	1000 and above

N.B For simplicity 305 and 1049 have been rounded to 300 and 1000 respectively.

Mode

We have already discussed the mean and the median as measures of central tendency. These are the more commonly used measures. Sometimes, however, we may be interested in the most typical value of a series or the value around which maximum concentration of items occurs. This value is called the mode. A garment manufacturer, specialising in men's shirts would like to know the size of shirts that has the maximum demand It is true that he would produce shirts of other sizes too, but his production will have to concentrate around this shirt size.

In case of ungrouped data, mode can be located by identifying the value which occurs most frequently. This, however, requires the data to be put in an array. When one value occurs more frequently than any other value, the distribution is called unimodal. If, however, two different values have equal and maximum frequencies associated with them, the distribution is known as bimodal. When all values of the observations are non-repetitive or unique, mode does not exist.

For grouped data the mode can be calculated by identifying the class with the highest frequency as follows :

$$M_o = L_1 + \frac{D_1}{D_1 + D_2} \times h$$

where L_1 = the lower limit of the modal class, i.e the class with the maximum frequency; D_1 = the difference between the frequency of the modal class and that of the preceding lower class. D_2 = the difference between the frequency of the modal class and that of the class following the modal class, and h = the magnitude of the modal class interval.

Example

Compute the modal income of workers' families from the following distribution

Income of Workers' Families in a City

Annual Income (Rs.)	No of Families
Less than Rs. 300	500
300 — 600	1500
600 — 1200	3000
1200 — 2400	6500
2400 — 3600	3500
3600 — 4800	1800
4800 — 8000	600
8000 — 15000	120
15000 and above	80
Total	17,600

$$\text{Mode} = L_1 + \frac{D_1}{D_1 + D_2} \times h$$

Here, the modal class is Rs, 1200—2400 and, therefore, $L_1 = 1200$, $D_1 = 6500 - 3000 = 3500$, $D_2 = 6500 - 3500 = 3000$, and $h = 2400 - 1200 = 1200$

$$\therefore \text{Mode} = 1200 + \frac{3500}{3500 + 3000} \times 1200$$
$$= 1200 + \frac{8400}{13} = 1200 + 646.15$$
$$= \text{Rs. } 1846.15$$

The modal annual income of worker families in this city is Rs. 1846 15.

The mode can be located easily by inspection and is an estimate that can be used effectively with people who do not understand statistical methods. It is, however, not a significant measure unless the number of observations is large. Further, though it can be used with unequal class intervals, it may present an untrue picture in some cases.

Like the median, the occurrence of a few extreme values has no effect on the mode, since by definition, it is the most typical value of a series Mode is not commonly used because a series may contain no point of concentration or may have two or more points of concentration. In these cases, mode is not uniquely defined. In case of highly skewed distributions, the mode will be at the end or the beginning of the distribution The mode, in such cases, ceases to be a measure of central tendency.

We may now draw certain important conclusions from the foregoing discussion which apply to all measures of central tendency.

An average can act as a measure of central tendency only if there is a substantial amount of concentration or clustering in the frequeney distribution, that is, if the variation is not too large. An average by itself does not disclose the degree of variation in a series and, therefore, if we have only an average, we cannot be sure whether or not it is an appropriate and meaningful measure of central tendency.

An average can serve as a useful measure of location for comparing two or more series, only if the series being compared have nearly the same shapes. Here again, one cannot tell from the averages alone whether they can serve as a useful measure of location.

Arithmetic mean may not be a useful measure of central tendency for another type of situation, namely, when the series is markedly non-symmetrical or skewed. The distribution of income, land holdings and other assets, and the ownership pattern of industrial activity are examples where frequency distributions are likely to be highly skewed in most countries and arithmetic mean may not be an appropriate measure of central tendency in these cases. However, since arithmetic mean has certain important properties, it is very widely used. These properties are

(i) The algebraic sum of deviations of a set of numbers from their mean is zero, i e. $\Sigma (X - \bar{X}) = 0$

(ii) The sum of the squares of the deviations of a set of numbers from their mean is the least, i e. $\Sigma (X - \bar{X})^2$ is minimum.

(iii) If f_1 numbers have mean m_1, f_2 numbers have mean $m_2 \ldots$, f_k numbers have mean m_k, the mean of all the numbers is

$$\bar{X} = \frac{f_1 m_1 + f_2 m_2 + \ldots + f_k m_k}{f_1 + f_2 + \ldots + f_k}$$

i e. the combined mean is the weighted arithmetic mean of all the means.

(iv) If "a" is any assumed arithmetic mean which may be any number and if $u_j = x_j - a$, the deviation of x_j from a, then we can find the mean, $\bar{X}$, easily from the assumed mean.

Mean, Median and Mode—A Relative Evaluation

While discussing the characteristics of each of the three measures of central tendency, we have pointed out that the choice of a particular measure of central tendency depends upon the distribution of data and the purpose for which the measure is to be used. The arithmetic mean undoubtedly remains the most commonly used measure. An important reason for its popularity is the fact that it is simple and is amenable to further mathematical manipulation. However, in series where there occur extreme values or open-end classes, the mean can be very misleading. Here, median will be a more appropriate measure of central tendency. The use of mode, as already noted, is rather limited.

Measures of Dispersion and Concentration

In the preceding pages we have discussed the more important methods of summarising the series through various measures of central tendency. These measures are extremely useful since they give a single representative value for the entire distribution. However, they fail to provide, as noted earlier, any information regarding the spread of values and other important characteristics of the data. The average income of persons in a country (per capita income) for example, is one of the measures, of the level of economic development of the country. However, it fails to give any idea about the distribution of income among the people. It does not tell us what is the gap between the rich and the poor. Nor does it show how many people are below the poverty line and how many have extremely high incomes. For giving a complete picture of any distribution, it is necessary to supplement the measures of central tendency by measures of dispersion or the internal variability of the data.

There are seven most commonly used measures of variability : (i) Range, (ii) Quartile deviation, (iii) Mean deviation, (iv) Standard deviation, (v) Relative dispersion, (vi) Lorenz curve, and (vii) Location quotient.

Range

Range is the simplest measure of variability. It is obtained by taking the difference between the highest and the lowest values in a given series. Suppose the monthly income of five persons is Rs. 180, 250, 170, 100 and 200 respectively. The lowest value of this distribution is 100 and the highest is 250. The difference between the two values, 250 — 100 = 150, is the range of this distribution. The range, as can be seen, is very easy to understand and calculate. However, since it depends on only two extreme values and ignores all other values, it can be highly misleading.

Example

Suppose we are given the incomes of 10 persons in two localities A and B as follows :

Income per month

Locality A : Rs. 70, 100, 50, 130, 140, 150, 90, 60, 110 and 600.

Locality B : Rs. 1250, 1350, 1600, 1450, 1550, 1700, 1750, 1800, 1400 and 1650.

Range

Locality A = 600 − 50 = Rs. 550

Locality B = 1800 − 1250 = Rs. 550

Mean

$\bar{X}_A$ = Rs. 150

$\bar{X}_B$ = Rs. 1550

The range in both the distributions is the same, i.e. Rs 550. However, the incomes in locality A lie between Rs. 50 and 600 and in locality B between Rs. 1250 and 1800. Further, the incomes within the two limits are differently distributed in the two localities. In locality A, there is only one value higher than the mean income ($\bar{X}_A$) of Rs. 150; on the other hand, in locality B, 4 values lie below $\bar{X}_B$ = Rs. 1550, and 5 above it. As can be seen, range is a crude measure of variability and should be used carefully only where the data are fairly continuous and not irregular.

Quartile Deviation

To avoid the effect of extreme values inherent in the range, we often measure variability by taking half the difference between the upper and the lower quartiles. This difference is called semi-interquartile range or quartile deviation (Q).

$$Q = \frac{Q_3 - Q_o}{2}$$

Although this measure avoids the effect of extreme values, it is not based on all the values in a series, *Mean Deviation*

A proper approach to the measurement of dispersion or variability would require that all the values in a series are taken into consideration. One of the methods of doing it is through average deviation or mean deviation. As the very name indicates, this measure is an average or the mean of the deviations of the values from a fixed point, which is usually the arithmetic mean and sometimes the median. We first find out the sum of the deviations, ignoring their signs, and then divide it by the number of the observations. By ignoring the signs of the deviations and considering only their magnitude, we do not allow them to cancel out each other, i.e., we give equal weight to positive and negative deviations. The student will recollect that the sum of deviations from the mean, $\Sigma (X - \bar{X}) = 0$. In algebraic terms, for ungrouped data,

$$\text{Mean Deviation (MD)} = \frac{\Sigma \mid (X - \bar{X}) \mid}{N}$$

The symbol | | known as modulus implies that we are considering only the magnitude of the variable within it, i e. ignoring the sign, $X - \bar{X}$ = the deviations of the values from the mean (or the median), and N = the total number of observations.

$$\text{For grouped data, MD} = \frac{\Sigma f \mid (X - \bar{X}) \mid}{N}$$

Here, $X - \bar{X}$ = the deviations of the class mid-points from the mean (or the median), and $N = \Sigma f$, which is the sum of the frequencies, i.e. the total number of observations.

Example

Let us calculate the mean deviation for the income of 10 persons in localities A and B as shown in tables below.

The mean deviation for locality A (Rs. 90) is smaller than that for locality B (Rs. 150). However, it should not be interpreted as indicating lower variability for income in locality A, because (i) locality A series, as noted earlier, is highly skewed and irregular whereas the series for locality B is near symmetrical, and (ii) the averages of the two series are far apart.

Locality A

Persons Sl. No.	Income (Rs) X_A	$X_A - \bar{X}_A$
1	70	80
2	100	50
3	50	100
4	130	20
5	140	10
6	150	0
7	90	60
8	60	90
9	110	40
10	600	450
Total	1500	900

$$X_A = 150$$

$$MD_A = \frac{\Sigma \mid X_A - \bar{X}_A \mid}{N} = \frac{900}{10} = \text{Rs. } 90$$

Locality B

Persons Sl. No.	Incomes (Rs) X_B	$X_B - \bar{X}_B$
1	1250	300
2	1350	200
3	1600	50
4	1450	100
5	1550	0
6	1700	150
7	1750	200
8	1800	250
9	1400	150
10	1650	100
Total	15500	1500

$$X_B = 1500$$

$$MD_B = \frac{\Sigma \mid X_B - \bar{X}_B \mid}{N} = \frac{1500}{10} = \text{Rs. } 150$$

Standard Deviation

Another method of measuring dispersion which is based on all the values in a distribution is the standard deviation. Here, we first find out the sum of the squares of the deviations from the mean and then divide it by the number of observations. The resultant is called the variance and its positive square root is defined as the standard deviation. It may be noted that, whereas in case of the mean deviation we ignored the negative signs of the deviations, here we achieve the same effect by squaring the deviations For ungrouped data,

Standard Deviation $(\sigma) = \sqrt{\frac{\Sigma(X-\bar{X})^2}{N}}$

The above formula becomes rather tedious if the value of the X involves decimal points and also if the number of observations is very large. We may then use the following short-cut method :

$$\sqrt{\frac{\Sigma X^2}{N} - \left(\frac{\Sigma X}{N}\right)^2}$$

Example

Let us calculate the standard deviation of the average annual rainfall of Jodhpur and Bikaner as given below for 10 years.

District	*Rainfall in inches*
Bikaner (X)	6.4 27.4 8.1 16.1 19.0 7.2 10.2 4.7 1.4 and 18.9
Jodhpur (Y)	8.7 14.6 25.1 30 6 22.7 9.4 15.0 15.3 9.0 and 11.3

Calculation of Mean and Standard Deviations

Bikaner				Jodhpur		
Year	Rain-fall (X)	$X-\bar{X}$	$(X-\bar{X})^2$	Rain-fall (Y)	$Y-\bar{Y}$	$(Y-\bar{Y})^2$
1	6.4	6.62	43 82	8 7	—7.47	55.80
2	27.4	14.38	206 78	14 6	—1 57	2.47
3	8.1	4.92	24.21	25 1	8 93	79 75
4	16 1	3 08	9.48	30.6	14 43	208.22
5	19.0	5.98	35 76	22.7	6.53	42 64
6	7.2	—5.82	33.87	9.4	—6 77	45 83
7	10 0	—3 02	9.12	15 0	—1.17	1.37
8	4.7	—8.32	69.22	15 3	—0.87	0.76
9	12.4	—0 62	0 38	9 0	—7.17	51 41
10	18.9	5 88	34 57	11 3	—4 87	23.72
	130.20		467 22	161.70		511.97

$$\text{Mean X} = \frac{\Sigma X}{n} = \frac{130.2}{10} = 13.02$$

$$\text{S.D} = \sqrt{\frac{\Sigma(X - x)^2}{n}} = \sqrt{\frac{467.22}{10}}$$

$$= \sqrt{46.722} \quad = 6.83 \text{ inches}$$

$$\text{Mean Y} = \frac{\Sigma Y}{n} = \frac{161\ 7}{10} = 16.17$$

$$\text{S.D.} = \sqrt{\frac{\Sigma(Y - \bar{Y})^2}{n}} = \sqrt{\frac{511.97}{10}}$$

$$= \sqrt{51.197} \quad = 7\ 16 \text{ inches}$$

	Bikaner	*Jodhpur*
S D. of rainfall	6.83 inches	7 16 inches
Mean of rainfall	13.02 inches	16.17 inches

It may be seen that the value of standard deviation 7.16 inches at Jodhpur is higher than that of 6.83 inches at Bikaner

In the section on graphical representation, we have discussed various types of frequency curves. Among those frequency curves, a bell shaped symmetrical curve known as normal curve is also discussed. The normal curve is very widely used in statistics, due to some of its important properties, which are as follows :

(i) In a normal distribution, the values of the mean, the median and the mode are identical.

(ii) The curve is symmetrically distributed around the value of the $\bar{X}$ (or the median or the mode).

(iii) In a normal distribution, a large proportion of observations are concentrated around the mean.

$\bar{X} \pm$ S D. covers 68.27 per cent of the observations.

$\bar{X} \pm$ 2S.D. covers 95 45 per cent of the observations

$\bar{X} \pm$ 3S.D. covers 99.73 per cent of the observations.

(iv) The two tails of the normal curve while approaching the X-axis never meet it, i.e. they are asymptotic to the X-axis.

These properties of a normal curve help in dividing the observations in four or six categories, provided that they are normally distributed.

Suppose the mean of a normal distribution is 50 with a standard deviation of 7, the limits of the three classess given above would be :

$\bar{X} \pm$ S.D.

$50 - 7$ to $50 + 7$, i.e. 43 to 57

$\bar{X} \pm 2$ S D.

$50 - 2 \times 7$ to $50 + 2 \times 7$, i.e. 36 to 64

$\bar{X} \pm 3$ S.D.

$50 - 3 \times 7$ to $50 + 3 \times 7$, i.e 29 to 71

Thus, the six classes can be worked out as :

Less than $\bar{X} - 2$ S.D.	Less than 36
$\bar{X} - 2$ S.D to $\bar{X}$ − S.D.	36 − 43
$\bar{X}$ − S.D. to $\bar{X}$	43 − 50
$\bar{X}$ to $\bar{X}$ + S.D.	50 − 57
$\bar{X}$ + S.D. to $\bar{X} + 2$ S.D.	57 -- 64
$\bar{X} + 2$ S.D. and above	64 and above.

Relative Dispersion

We have so far been discussing the absolute measures of dispersion. These absolute measures fail to give us a precise idea about the variability without reference to the central tendency of the series.

Further, absolute measures of dispersion do not enable us to make comparison between two or more distributions which are expressed in different units or even when expressed in the same units have widely different means. In these cases, we will have to use some relative measure of dispersion. The most commonly used measure of relative dispersion is the coefficient of variation (C. V.) given by .

$$C.V = \frac{\sigma}{X} \times 100$$

To stress the importance of relative variability, consider the variability of rainfall in Bikaner and Jodhpur as given in the previous example. The mean annual rainfall in Bikaner was found there as 13.02. As the mean of rainfall over 10 years differs from each other, the variability of it cannot be compared through standard deviations. The standard deviation of rainfall in Bikaner is 6.83 inches and in Jodhpur it is 7.16 inches. If we compare their rainfall variability in relation to their mean level of rainfall through the coefficient of variations, we get :

	Bikaner	*Jodhpur*
S D of rainfall	6.83 inches	7.16 inches
Mean of rainfall	13.02 inches	16.17 inches
C.V.	$\frac{6.83}{13.02} \times 100 = 52.46$	$\frac{7.16}{16.17} \times 100 = 44.28$

Thus, we see that the C.V. is higher in Bikaner than in Jodhpur. Hence, we have to conclude that rainfall is more inconsistent or more variable in relation to its mean in Bikaner than in Jodhpur It is important to note here that the standard deviation shows just the reverse position in terms of absolute variability.

Lorenz Curves

Quite often we are interested in studying the problem of inequality in the distribution of income, expenditure, wealth land holdings and other assets. The Lorenz curve provides a very useful tool to study these problems.

Let us take the case of income distribution. We would say that income is absolutely equitably distributed in a country if n per cent of the population has n per cent of the national income. This means that one per cent of the population have one per cent of the total income, two per cent have two per cent total income, ten per cent of the population have ten per cent of the total income and so on. We plot the cumulative percentage of their population on X-axis and the corresponding share in total income on the Y-axis. The line of equal distribution will then be the 45 degree line. The Lorenz curve is a measure of the deviation of actual distribution from the line of equal distribution. The following example will make it clear.

Example

The distribution of holdings in India by size is given below for 1961-62. Prepare a Lorenz curve to show the inequality in the size distribution of the holdings.

For a Lorenz curve showing holdings with their respective areas, we must have the values given in 2nd and 3rd columns in percentage to

Area of holdings (in hectares)	Number of holdings (in million)	Area of holdings (in million)
Less than 1	19 8	9.2
1 — 3	18 0	32.1
3 — 5	6 1	23 0
5 — 10	4 5	30.6
10 — 20	1 8	23.1
20 and above	0 5	15.1
Total	50 7	133.5

Source : National Sample Survey, 17th Round,

their totals as given in the following Table. These percentages are then accumulated for each column. The various cumulative frequencies of one column are plotted on the X-axis and the corresponding cumulative values of the other column on the Y-axis. These consecutive points are joined to get Lorenz curve (Fig 58).

Area of holdings (in hectares)	Percentage of		Cumulative percentage of	
	Holdings	Area	Holdings	Area
Less than 1	39 1	6 9	39 1	6.9
1 — 3	35.5	24 1	74.6	31.0
3 — 5	12.0	17 2	86 6	48.2
5 —10	8 9	22.9	95 5	71.1
10 —20	3 5	17 3	99.0	88 4
20 and above	1.0	11.6	100.0	100.0
	100.0	100.0		

The two end points of the curve are also joined by a diagonal to show the line of equal distribution.

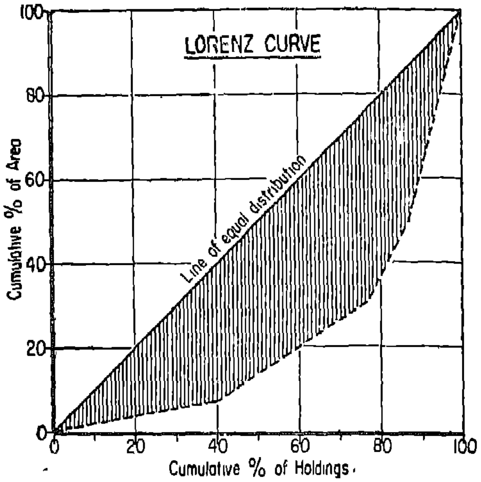


Fig. 58. Lorenz Curve

Location Quotient

Often we are required to measure the geographical distribution of an industry or any other economic activity in different regions of the country. For this purpose, it is just not enough to map the data on the related economic activities. We are interested in measuring the relative importance of one industry among all industries in the region, and compare the same with reference to the national level. Such a measure is called the location quotient (L. Q.). It is worked out on the basis of the following formula.

Let Ws be the number of workers engaged in a sugar industry in region M, Wi the number of workers engaged in all the industries in region M, Ns the number of workers engaged in the sugar industry for the country as a whole, and Ni the number of workers engaged in all the industries in the country as a whole. In this case the location quotient of M or $L.Q._M$ would be given by :

$$L.Q._M = \frac{\frac{Ws}{Wi}}{\frac{Ns}{Ni}}$$

The values of L. Q. worked out in this way for all the regions of a country can be mapped in order to measure the pattern of distribution and concentration of industries in different parts of the country. It gives the proportion of the particular characteristics to its total within an area, in relation to the corresponding proportion for the nation (or region).

If the ratio of the proportion of any area to the national proportion (i.e. L.Q.) is greater than 1, it shows the concentration. However, if the ratio is equal to unity it is showing neither concentration nor dispersion. A value of this ratio of less than 1, on the other hand, shows the dispersion of that characteristic over that area.

While interpreting L.Q., one should note the following :

(i) They are the ratios of ratios and, hence, are only simple numbers without any unit.

(ii) Because L.Qs. do not bear any unit, they are comparable.

(iii) The advantage of L.Q. is that it does not require extensive data and is easily understood.

The L.Q. can also be used for measuring the concentration of any sub-group of population in relation to total population.

The computation of L.Q. by taking the data on population of schedule castes and tribes of the districts of Assam, Meghalaya and Mizoram in relation to their total population is explained below.

Example

District	Total population	Population of S.C.*	Population of S.T.†
Goalpara	2225103	120006	308287
Kamrup	2854183	164762	298090
Darrang	1736188	77104	185640
Nowgong	1680995	167262	125311
Sibsagar	1837389	86120	125311
Lakhimpur	2122719	77789	286300
Mikir Hills	379310	9820	210039
N. Cachar Hills	76047	826	52583
Cachar	1713318	208867	15282
Mizo Hills	332390	82	313299

* S.C.—Scheduled Caste. † S.T.—Scheduled Tribe.

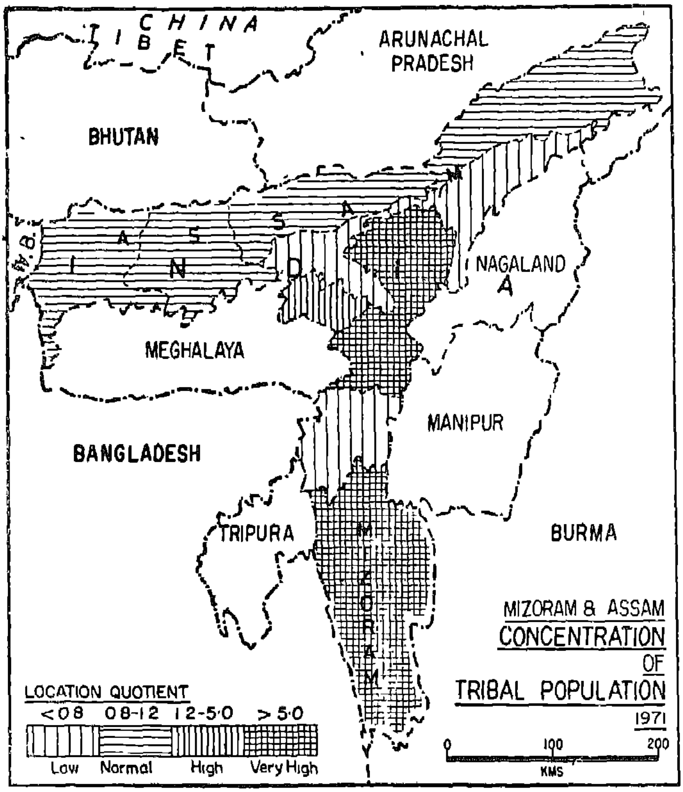
The district-wise total population and the population of scheduled castes and tribes in Assam, for 1971 are given above. Find out the areas of relative concentration of tribal population and of scheduled caste population.

Solution

The percentages of scheduled caste and scheduled tribes to the total population have been worked out for each district and also for the whole of Assam and are given in cols 2 and 3 of the Table below. To get the L.Q.s, these district-wise percentages have been divided by the same percentage in the region (Assam) and the resultant values are also given in cols 4 and 5.

District	Percentage of S.T, to total population	Percentage of S C. to total population	L.Q. for S.T.	L.Q. for S.C.
Goalpara	13.85	5.39	1.08	0.88
Kamrup	10.44	5.77	0.81	0 95
Darrang	10.69	4.44	0.83	0.73
Nowgong	7.44	9 95	0 58	1.63
Sibsagar	6.82	4.69	0.53	0.77
Lakhimpur	13.45	3.67	1.05	0.60
Mikir Hills	55.37	2.59	4.31	0.42
N. Cachar Hills	59.15	1.22	5.39	0.20
Cachar	0.89	12.19	0.07	2.00
Mizo Hills	94.26	0.03	7.34	0 004
Assam	12 84	6 10		

The values of the L.Q. show a higher concentration of scheduled tribes in Mizo Hills, North Cachar Hills and in Mikir Hills as L.Q. in these districts is greater than 1. In Goalpara and Lakhimpur, it is quite balanced. In all other districts, the population of scheduled castes is much dispersed. The values of location quotient for scheduled tribes when plotted on a map, give a good picture of spatial concentration or dispersion of the phenomenon under consideration (Fig. 59).



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The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

Fig. 59. Location Quotient—Concentration of Tribal Population

Similarly, the population of scheduled castes is also found to be highly dispersed in the districts except in Cachar and Nowgong where it has a higher concentration (as the value of L.Q. is greater than unity in these districts).

Composite Measurement of Several Variables

The value of a single variable of an area throws some light on certain particular dimension of its socio-economic status. This single value, however, may not be sufficient enough to portray the related aspects fully.

For example, percentage of urban population to total population does not describe spatial process of urbanisation fully. It is not capable of throwing light on other aspects of urbanisation, such as occupational status of people, their education, industrial base of the area, their living conditions, etc. Thus, the process of urbanisation has to be studied through its several indicators. Similarly, agricultural development is also partially reflected in various aspects of agriculture, such as, production per hectare, level of irrigation, consumption of fertilizers, etc.

Extracting a composite picture from a given set of variables is an important concern of the geographers in portraying multivariable data on a single map. There are several methods of doing this, depending on the nature of data and the objective of the study. The simplest one of them is the Kendall's ranking method as discussed below.

Kendall's Ranking Method[1]—While measuring the agricultural efficiency in England and Wales, the noted statistician, M.G. Kendall took county-wise data on per acre production of different crops. The yields of these crops were then converted into their ranks and these ranks were added to give the composite ranking of the counties in terms of their overall agricultural productivity. Thus, if R_{ij} is the rank of ith crop in jth district, its composite index of crop productivity I_j is given by

$$I_j = \Sigma R_{ij} \qquad i = 1, 2, \ldots, n$$

where n is the number of selected crops. The districts are again ranked according to the total rank scores.

The ranking method of construction of a composite index is illustrated in the following example by taking the district-wise data for Rajasthan.

Example

The production (in metric tonnes) per hectare of five important crops in the districts of Rajasthan for 1970-71 is given in the Table below. Construct the composite index of agricultural productivity using the ranking method.

Yield in Metric Tonnes per Hectare in Rajasthan : 1970-71

District	Maize	Bajra	Jowar	Barley	Gram
Ajmer	.085	.667	.343	1.378	.551
Alwar	.905	.567	.611	1.640	.991
Banswara	1.309	—	.436	1.545	.053
Barmer	—	.496	.413	1.333	.500
Bharatpur	·001	1 107	.403	1 020	.658
Bhilwara	1.008	·518	.196	1.293	.470
Bikaner	—	.156	.500	—	1.000
Chittorgarh	1.801	—	.632	1.577	.482
Churu	—	.251	500	—	.418
Dungarpur	.868	.005	.434	1.568	.316
Ganganagar	1.307	951	.405	756	.692
Jaipur	3.397	679	.444	1.767	1 248
Jaisalmer	—	180	.400	—	.666
Jhalawar	1.303	509	.583	1 500	.406
Jhunjhunu	—	.520	.500	1.516	.314
Jodhpur	.001	.527	292	1.133	.552
Kota	1.443	.521	.624	1 456	581
Nagaur	1 142	.307	.275	1.204	.554
Pali	.806	.851	.512	1 199	558
Sawai Madhopur	·091	.880	.799	1.435	825
Sikar	—	.480	.500	1.773	.814
Sirohi	1 083	.530	.393	1.950	.553
Tonk	1 004	.668	.355	1.395	.736
Udaipur	1.320	.500	.365	1.284	.775
Bundi	1.387	.571	.576	1 464	.594
Jalore	2.000	.081	.419	1.190	.558

Dash (—) means negligible.

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[1] M.G. Kendall, The geographical distribution of crop productivity in England, *Journal of Royal Statistical Society*, **21** (1939), 102.

Solution

Using Kendall's method, the productivity of all the 26 districts has to be ranked separately for each crop. Thus, every district will have five ranks each for different crops. The sum of the five ranks of a district will give the composite scores reflecting agricultural productivity of the districts. In the Table below, the districts have been ranked five times according to their yield per hectare in each of the five crops. The district having highest yield has been assigned first rank, the next highest the 2nd rank and so on. Variations in agricultural productivity by composite ranking are brought out in Fig. 60.

Problem of Ties—In some cases, the yield of few districts is equal for certain crops. This problem of "ties" is a common problem in any ranking procedure. To avoid this complication it is necessary to give them a rank value equal to the average of the successive ranks given to them. For example, the yield of Jowar is 0.5 in Bikaner, Sikar, Jhunjhunu and Churu districts. The previous highest value is 0.512 whose rank is 7. We assign successive ranks to the next four values, all equal to 0.5, as 8,.9, 10, 11. The average of these is 9.5. So each of them should be assigned 9.5 as its rank. The next lowest value 0.485 in Ganganagar has been ranked 12 and others as usual. The same rule

Yield Ranks of Districts (Rajasthan)

District	Maize	Bajra	Jowar	Barley	Gram	Total	Composite rank
Ajmer	19	7	23	15	15	79	16
Alwar	14	9	4	5	3	35	3
Banswara	8	25.5	14	8	26	85.5	20
Barmer	23.5	18	17	16	19	93.5	24
Bharatpur	15.5	1	18	23	10	67.5	13
Bhilwara	12	14	26	17	21	90.0	23
Bikaner	23.5	23	9.5	25	2	83.0	19
Chittorgarh	4	25.5	2	6	20	57.5	8
Churu	23.5	21	9.5	25	22	101.0	26
Dungarpur	18	16.5	15	7	24	80.5	18
Ganganagar	9	2	12	4	8	35.0	4
Jaipur	1	5	13	3	1	23.0	1
Jaisalmer	23.5	22	19	25	9	98.5	25
Jhalawar	10	15	5	10	23	63.0	11
Jhunjhunu	23.5	13	9.5	9	25	80.0	17
Jodhpur	15.5	11	24	22	17	89.5	22
Kota	5	12	3	12	2	34.0	2
Nagaur	11	20	25	18	15	89.0	21
Pali	20	4	7	19	13.5	63.5	12
Swai Madhopur	17	3	1	13	4	38.0	5
Sikar	23.5	19	9.5	2	5	59.0	9
Sirohi	3	10	20	20	16	69.0	14
Tonk	13	6	22	14	7	62.0	10
Udaipur	7	16.5	21	1	6	51.5	7
Bundi	6	8	6	11	11	42.0	6
Jalore	2	24	16	21	13.5	76.5	15

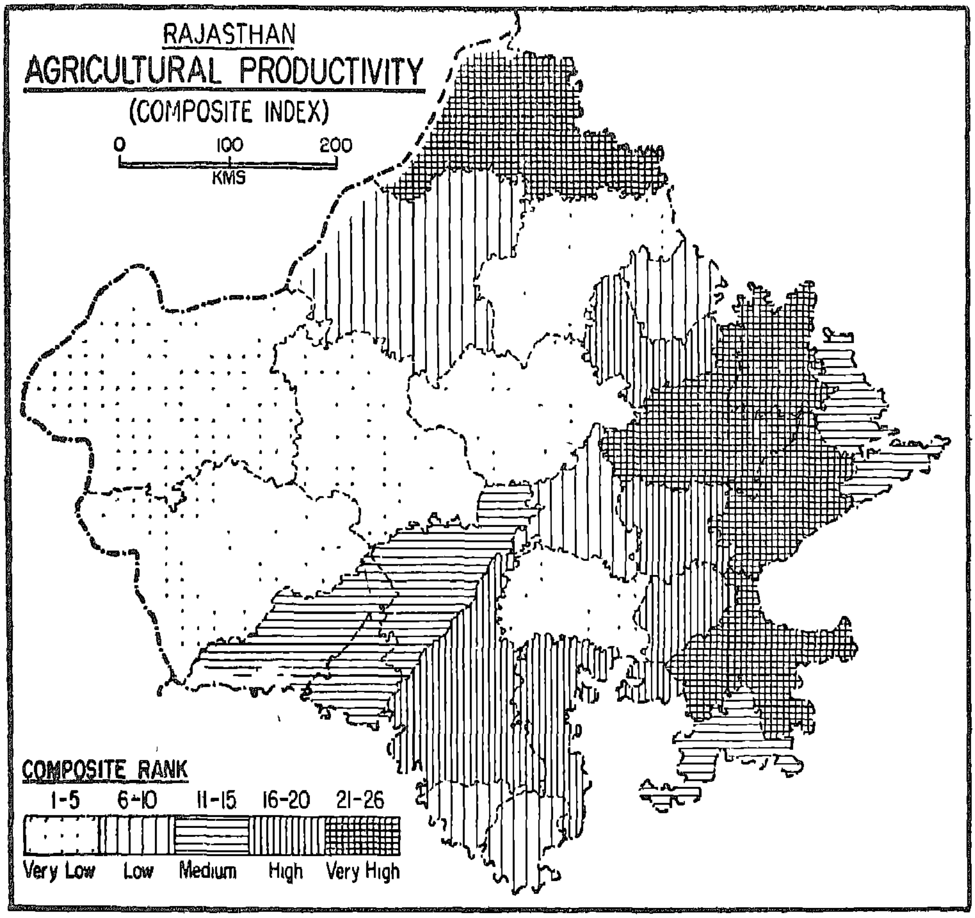

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Fig. 60. Composite Index of Agricultural Productivity

will apply to any number of districts having equal yields

Thus, the composite rank given in the last column shows the overall agricultural productivity of all the districts based on these five crops. According to this exercise, Jaipur is the most agriculturally productive district because its value of the composite score is the least. Kota is the next agriculturally productive district followed by Ganganagar, Alwar, and so on. The least agriculturally productive district is Churu whose composite rank is 26. The ranking method, in spite of having the advantage of simple computations, has some serious disadvantages also. When we rank the districts according to their yield of a crop, the absolute differences are ignored. For example, suppose the highest value of yield of a crop is 0.95, it's next highest value 0.94, and the third highest value 0.70. We will rank them 1, 2 and 3. Thus, the difference of 0.05 units in the first two districts adds one rank to the second district, whereas the difference of 0.20 units in the 2nd and 3rd districts also adds only one rank to the third district.

Another serious drawback of this method is that the ranks of all the crops are treated with equal importance, irrespective of their proportional area.

Index Numbers

We can measure the relationship between two features that make up the geographical landscape in a graphic form by the use of index numbers; for example, when we want to know the relationship between the growth of population and growth of non-agricultural activity in India during a certain period of time.

Index number refers to a term in a time series expressed as a relative number. The Table below gives the data on population and non-agricultural employment for the period 1920-1964.

Year	Population (thousand)	Relative index 1930=100	Non-Agril employment (thousand)	Relative index 1930=100
1920	104466	85	27088	93
1930	123077	100	29143	100
1940	132122	107	32058	110
1950	151683	123	44738	154
1960	179323	146	52898	182
1964	192119	155	58188	200

Source: Maurice, H Yeates, *An Introduction to Quantitative Analysis in Economic Geography*, McGraw-Hill, Inc, New York, 1968.

From the above Table, the total non-agricultural employment was 58,188,000 in 1964 and 29,143,000 in 1930. If the index number is calculated with 1930 as the base year for which the value is assigned as 100,

$$\text{Index number} = \frac{58{,}188{,}000}{29{,}143{,}000} \times \frac{100}{1}$$

$$= 199.66 = 200$$

The advantages of representing numbers in a time series relative to a fixed base are threefold. First, large numbers are simplified and, therefore, become much easier to use. In the above example, 29,143,000 is assigned the index number 100 and 58,188,000 becomes 200—numbers that are obviously far easier to handle. Secondly, because large numbers are simplified, comparison between series of numbers is greatly facilitated. Thirdly, when the series are transformed to index numbers relative to the same base year, a study of changes is emphasised and the overwhelming effect of the magnitude of numbers eliminated.

Measurement of Relationships

It is a common experience in our country that the level of agricultural production depends on the monsoons. In a year of good rainfall, the agricultural production is high. We also know that farms with assured irrigation have generally a higher productivity per hectare than unirrigated ones. These are examples of relationships between two variables. Very often the relationships might involve three or more variables. For example, productivity per hectare may be related to not only irrigation, but also to the quality of seeds, fertilisers and pesticides used, and so on.

It may be stressed that the mere existence of a relationship between two variables does not necessarily mean that one is caused by the other. In most countries, population and national income have grown over time. However, this does not mean that the passage of time is a cause of the growth of population or national income. Obviously, factors other than the passage of time are responsible for their growth.

The measurement of the nature and degree of relationship between variables is called correlation and that between attributes is called association. We will confine ourselves here to a discussion of simple correlation, i.e. relationship between two variables. Agricultural production, for example, will vary from one area to another, if the level of irrigation and other factors affecting it also vary. In this case, the agricultural productivity is said to be the dependent variable and irrigation and other characteristics influencing it are said to be independent variables. Other things being equal, agricultural productivity would be higher in better irrigated areas In any such case, where higher values of the dependent variable are found with higher values of the independent variable, the two variables are said to be positively correlated Theoretically, positive correlation may be found in the variables of : (i) urbanisation and industrialisation, (ii) industrial production and employment, and (iii) immigration and the density of population On the other hand, if the higher values of one variable are found with smaller values of the other, the variables are said to be negatively correlated. The example of the negatively correlated variables could be: (i) literacy and proportion of rural population or (ii) agricultural production per hectare and aridity. In case there is no correlation between the values of two variables, they are said to be independent.

Correlation, as noted earlier, only indicates the degree and direction of relationship between two variables. It does not, necessarily, connote a cause-effect relationship, as shown in our example of growth of population and national income over time. Even when there are grounds to believe that causal relationship exists, correlation does not tell us which variable is the cause and which the effect. For example, the demand for a commodity and its price will generally be found to be correlated, but the question whether demand depends on price or *vice versa* will not be answered by correlation.

The answer to this type of questions cannot be provided by statistics; it is the function of theory to answer these. But, once theory tells us the direction of causal relationship through theoretical postulates, statistical methods can help to test it.

Identification of causal relationships is an essential concern of any scientific investigation. A better understanding of these causal relationships helps in predicting, influencing and controlling the future course of a given phenomenon. This is extremely important for policy decisions.

Simple correlation, as has been seen earlier, refers only to the relationships between two or more variables. Correlation does not indicate any causal relationship. However, in many cases, the first step in understanding may be to find if any relationship exists between any two (or more) variables. This knowledge can then help in suggesting theoretical hypotheses regarding the cause and the effect.

The nature of the relationships between any pair of variables can be studied graphically by scatter diagram and mathematically also by working out the coefficient of correlation.

Scatter Diagram—It is a simple way of looking at the relationship between any two variables by plotting the values of one of the variables on the X-axis and the corresponding values of the other variable on the Y-axis. In this way, we can represent each observation as a point on a graph. The cluster of points on a graph is known as a scatter diagram. If these points show an upward slope, a positive correlation can be inferred between the two variables. If the slope of the points is found to be downward, it shows a negative correlation. If, however, the points do not show any pattern, the two variables are said to be independent. Fig. 61 shows such scatter diagrams. The closeness of the points to a line shows the intensity of their relationship.

Correlation Coefficient—Scatter diagram is useful insofar as it gives a general idea about the direction and degree of correlation between two variables. However, graphical methods fail to give a quantitative measure of the degree of relationship. For this, we have a few quantitative measures. The simplest of these is the coefficient of rank correlation[1], R_k, given by .

$$R_k = 1 - \frac{6\Sigma d^2}{n^3 - n}$$

where n is the number of observations and d,

---

[1] The rank correlation measures only linear correlation, i e. the relationship shown by a scatter diagram moving around a straight line,

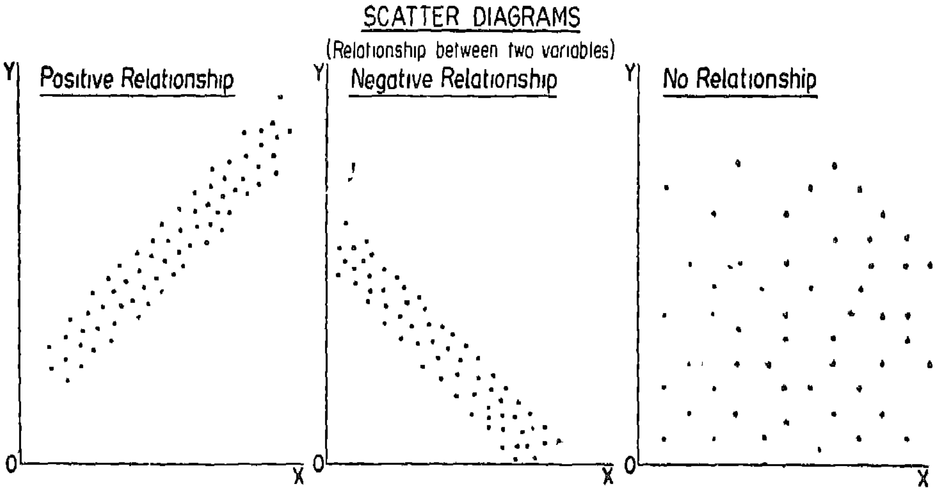


Fig. 61. Scatter Diagrams Showing Relationship between Two Variables

the difference of the ranks of the two variables.

If the value of R_k is negative, it shows the presence of negative correlation and if it is positive it shows the presence of positive correlation between the two variables. The zero value of R_k shows that there is no correlation between the two variables. The maximum value of R_k is unity (plus or minus). Thus, the value of R_k between zero and one shows the intensity of correlation from the lowest to the highest.

The following example will further clarify the above concept.

Example

Percentage of literates to total population and percentage of rural population to total population is given below for the States of India in 1971. Show the data on a scatter diagram and also work out a coefficient of rank correlation.

Solution

For showing the data on scatter diagram we plot one set of the values of each district on X-axis and the other values on Y-axis. The values when plotted on the graph we get the scatter diagram (Fig. 62) which suggests a negative correlation between literacy and share of rural population in the States of India (as the

State	Percentage of literates to total population	Percentage of rural to total population
Andhra Pradesh	21 19	80.65
Assam	27.47	91.61
Bihar	18.40	89.96
Gujarat	30.45	71.87
Haryana	19.93	82.22
Himachal Pradesh	21 26	92.94
Jammu and Kashmir	11 03	81.74
Kerala	46 85	83.72
Madhya Pradesh	17.13	83.74
Maharashtra	29 82	68.80
Karnataka	25 40	75.69
Nagaland	17.91	90.09
Orissa	21.66	91.28
Punjab	26 74	76.20
Rajasthan	15.21	82.39
Tamil Nadu	31.41	69.72
Uttar Pradesh	17.65	86.00
West Bengal	29.28	75.41

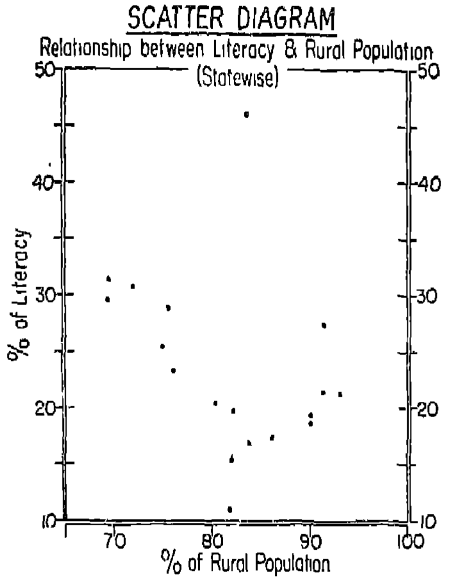


Fig 62. Scatter Diagram

points show a downward slope). The correlation, however, does not seem to be very strong, as these points are not falling around a line. In order to measure the intensity of this relationship a rank correlation coefficient is worked out in the following manner.

The values of literacy and proportion of rural population are first converted into their ranks and are given in the 2nd and 3rd columns of the following Table. The difference of these ranks is also given in column 4 and the squares of these differences are given in column 5. If the sum of these square rank differences is denoted as Σd^2 the rank correlation coefficient, R_k, is given by $R_k = 1 - \frac{6\,\Sigma\, d^2}{n^3 - n}$ when n is the number of observations. From the Table we get $\Sigma d^2 = 1388$, and $n = 18$.

$$R_k = 1 - \frac{6 \times 1388}{18 \times 18 \times 18 - 18}$$

$$= 1 - \frac{8328}{5832 - 18}$$

State	Rank of percentage Literacy population	Rank of percentage Rural population	Difference (d)	d^2
(1)	(2)	(3)	(4)	(5)
Andhra Pradesh	11	12	− 1	1
Assam	6	2	− 4	16
Bihar	13	5	− 8	64
Gujarat	3	16	−13	169
Haryana	12	10	2	4
Himachal Pradesh	10	1	9	81
Jammu and Kashmir	18	11	7	49
Kerala	1	8	− 7	49
Madhya Pradesh	16	7	9	81
Maharashtra	4	18	−14	196
Mysore	8	14	− 6	36
Nagaland	14	4	10	100
Orissa	9	3	6	36
Punjab	7	13	− 6	36
Rajasthan	17	9	8	64
Tamil Nadu	2	17	−15	225
Uttar Pradesh	15	6	9	81
West Bengal	5	15	−10	100
Total				1388

$$= 1 - \frac{8328}{5814} = 1 - 1.43$$

$$= -0.43$$

R_k is negative which indicates that there is a negative correlation between literacy and rural proportion, i.e. a district with high proportion of rural population tends to have lower literacy.

As the maximum value of R_k cannot exceed unity (+ or −), the value 0.4 does not indicate a very strong correlation. However, a given value of R_k based on a larger number of observations is better than that based on smaller number of observations.

APPENDIX I

Representative Fractions with their Metric and British Equivalents

Map scale (R. F.)	One centimetre represents	One kilometre is represented by	One inch represents	One mile is represented by
1 : 2,000	20 metres	50.0 cm	56 yards	31.68 inches
1 : 5,000	50 metres	20.0 cm	139 yards	12.67 inches
1 : 10,000	0.1 km	10.0 cm	0.158 mile	6.34 inches
1 : 20,000	0.2 km	5.0 cm	0.316 mile	3.17 inches
1 : 24,000	0.24 km	4.17 cm	0.379 mile	2.64 inches
1 : 25,000	0.25 km	4.0 cm	0.395 mile	2.53 inches
1 : 31,680	0.317 km	3.16 cm	0.5 mile	2.0 inches
1 : 50,000	0.5 km	2.0 cm	0.789 mile	1.27 inches
1 : 62,500	0.625 km	1.6 cm	0.986 mile	1.014 inches
1 : 63,360	0.634 km	1.58 cm	1.0 mile	1.0 inch
1 : 75,000	0.75 km	1.33 cm	1.18 miles	0.845 inch
1 : 80,000	0.8 km	1.25 cm	1.26 miles	0.792 inch
1 : 100,000	1.0 km	1.0 cm	1.58 miles	0.634 inch
1 : 125,000	1.25 km	8.0 mm	1.97 miles	0.507 inch
1 : 250,000	2.5 km	4.0 mm	3.95 miles	0.253 inch
1 : 500,000	5.0 km	2.0 mm	7.89 miles	0.127 inch
1 : 1,000,000	10.0 km	1.0 mm	15.78 miles	0.063 inch

APPENDIX II

Important Properties of Some Common Projections

Projection and its suitability	Properties
Simple cylindrical (Suitable for mapping areas in low latitudes, i e equatorial regions.)	1. It is neither equal-area nor orthomorphic. 2. All parallels are equal to the equator and all meridians are half of the equator in length 3 Parallels and meridians are spaced at equal intervals 4. Parallel scale is correct only along the equator It gets exaggerated poleward. Meridian scale is correct throughout. 5. The poles are projected as straight lines.
Cylindrical equal-area (Suitable for representing countries adjoining the equator and also used for world distribution maps.)	1. It is equal-area but not orthomorphic. 2. All parallels are spaced unequally, becoming closer towards poles while all meridians are spaced at equal intervals. 3. Parallel scale is correct only along the equator. It gets exaggerated towards north and south Meridian scale is not correct throughout It diminishes towards the poles 4. The poles are projected as straight lines.
Simple conical with one standard parallel. (Suitable for showing regions in mid-latitudes where latitudinal extent may be less than 20°.)	1. It is neither equal-area nor orthomorphic. 2. Parallels are arcs of concentric circles and meridians are straight lines radiating from the centre at uniform angular intervals. 3. Parallel scale is correct only along the standard parallel while to the north and south of it, it is exaggerated. Meridian scale is correct everywhere. 4. The pole is projected as an arc of a circle.
Zenithal equidistant (Suitable for polar regions not exceeding 30° in latitudinal extent around the pole.) (The area is correct only in Zenithal Equal Area)	1. It is neither equal-area nor orthomorphic. 2. Parallels are equidistant concentric circles and meridians are evenly spaced radiating lines from the centre. 3. Every point is at its true distance and in the right direction from the centre, i.e , the pole. 4. Parallel scale is not correct as it increases rapidly away from the centre. Meridian scale is correct throughout.

APPENDIX III

Topographic Maps of the Survey of India

The Survey of India was established in 1767 Besides giving training to many British surveyors, it has trained many Indian surveyors who are held in high esteem. Since its establishment, this organisation has published topographic sheets in a number of series.

The International Series

The scale of this series is 1 : 1,000,000. Each sheet extends over 4° of latitude and 6° of longitude. In this series, the elevation is shown in metres. These sheets are known as 1/m sheets or one to one million sheets.

India and Adjacent Countries Series

The scale of this series is also 1 1,000,000, but the whole country is divided into 4×4 degree sheets. That is, each map contains 4° of latitude and 4° of longitude. Indian maps in this series are numbered as 45, 46, 47 ......and so on. This series forms the base and also the basis of arrangements of all other topographic sheets of India (Fig. 63).

Quarter-inch to a Mile Series

The maps of this series are on the scale of one inch to 4 miles or 1 : 253,440. In this series, each 4×4 degree sheet is subdivided into 16 equal sheets. These are called the degree sheets since each sheet covers 1° of latitude and 1° of longitude and are numbered from A to P, e.g. 55A, 55B, 55C and 55P (Fig. 63).

Half-inch to a Mile Series

Half-inch sheets show an extent of 30′ of latitude and longitude and represent a scale of one inch to 2 miles or 1 · 126,720 These sheets are numbered with respect to their direction from the centre of the degree sheet. For example, half-inch sheets of sheet No 55A will be 55A/N W., 55A/N.E., 55A/S.W. and 55A/S.E. (Fig 63).

One-inch to a Mile Series

The R.F. of this series is 1 · 63,360. The maps drawn on this scale are undoubtedly the best known. This scale is capable of showing fairly accurate details Each sheet covers approximately 1800 square kilometres and shows an extent of 15′ of latitude and longitude

In this series, each degree sheet is subdivided into 16 parts These sheets are called one-inch topographic sheets. In other words, if each quarter-inch sheet is divided into 16 parts, they become one-inch maps They are numbered as 55A/1, 55A/2, . .and 55A/16 ; and 55B/1—16..... 55P/1 to 16 (Fig. 63). For the change-over from the British system to the metric system, the following metric scales have been specified for topographic maps.

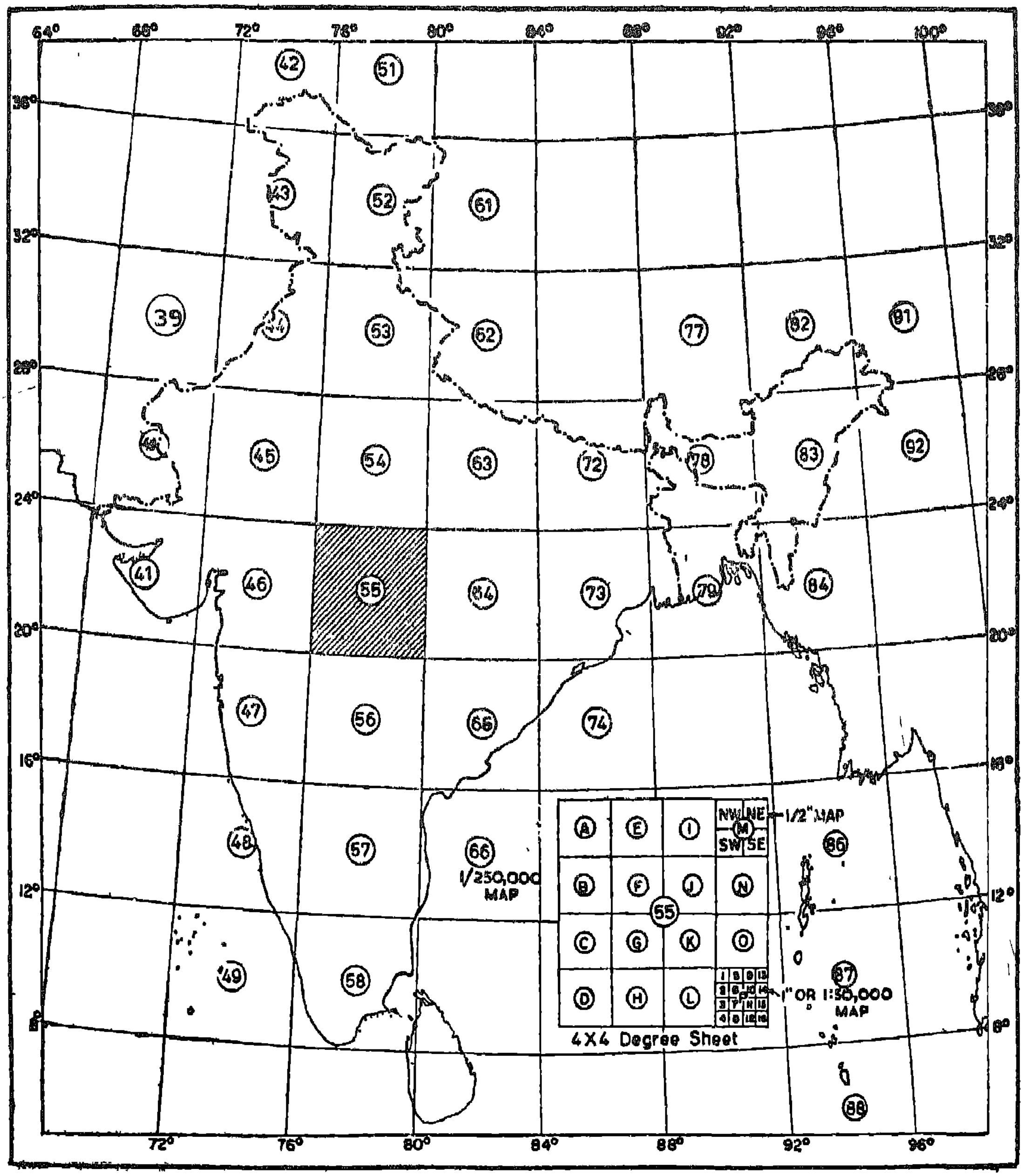
(i)	1 centimetre to 2.5 kilometres	(1 : 250,000)
(ii)	1 centimetre to one kilometre	(1 · 100,000)
(iii)	1 centimetre to 0.5 kilometre	(1 : 50,000)

The topographic sheets issued by the Survey of India may be had from ·

(i) The Director, Map Division, Survey of India, Hathibarkala, Dehra Dun.

(ii) The Deputy Director, Map Publication, Survey of India, 13, Wood Street, Calcutta-16.

(iii) The Incharge, Map Sales Office, Survey of India, Janpath Barracks 'A', First Floor, New Delhi-1.



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

Based upon Survey of India map with the permission of the Surveyor General of India.

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Fig. 63. Reference Map of Topographic Sheets Published by the Survey of India

APPENDIX IV

Altitudes, Pressures and Temperatures

Altitude (metres)	Pressure (millimetres)	Temperatures (°C)	Altitude (metres)	Pressure (millimetres)	Temperature (°C)
— 500	806.2	+ 18.3	6,000	353.8	— 24.0
0	760.0	15.0	6,500	330.2	— 27.3
500	716.0	11.7	7,000	307.8	— 30.5
1,000	674.1	8.5	7,500	286.8	— 33.7
1,500	634.2	5.2	8,000	266.9	— 37.0
2,000	596.2	+ 2.0	8,500	248.1	— 40.3
2,500	560.1	— 1.2	9,000	230.5	— 43.5
3,000	525.8	— 4.5	9,500	213.8	— 46.7
3,500	493.2	— 7.8	10,000	198.2	— 50.3
4,000	462.2	— 11.0	10,500	183.4	— 53.3
4,500	432.9	— 14.2	11,000	169.7	— 55.0
5,000	405.1	— 17.5	11,500	156.9	— 55.0
5,500	378.7	— 20.8	12,000	145.0	— 55.0

APPENDIX V

Relative Humidity as a Percentage

The ratio between the actual humidity of air and its maximum capacity to hold moisture at a given temperature is known as relative humidity. It is always expressed as a percentage. After taking the dry bulb and wet bulb readings at a given place and time, the relative humidity can be found from the following Table. This Table has been standardised on the basis of many observations and experiments conducted at the normal pressure of 76 centimetres at sea level.

Suppose, for any sample of air at a certain place, the dry bulb temperature is 90°F and the wet bulb reading is 82°F The difference between the two is 8°F. Now, find out 90°F in the "Dry bulb temperature" column, and 8 in the "Difference in degrees between dry bulb and wet bulb readings" line. At the intersection of 90°F and 8, you get the number 71 which is the relative humidity expressed as a percentage for that instant of time at that place.

When dry bulb and wet bulb readings are the same, the relative humidity is 100 per cent, that is the air has reached its saturation point

Dry bulb temperature in ° F	Difference in degrees between dry bulb and wet bulb readings													
	1	2	3	4	6	8	10	12	14	16	18	20	25	30
0	67	33	1											
5	73	46	20											
10	78	56	34	13										
15	82	64	46	29										
20	85	70	55	40	12									
25	87	74	62	49	25	1								
30	89	78	67	56	36	16								
35	91	81	72	63	45	27	10							
40	92	83	75	68	52	37	22	7						
45	93	86	78	71	57	44	31	18	6					
50	93	87	80	74	61	49	38	27	16	5				
55	94	88	82	76	65	54	43	33	23	14	5			
60	94	89	83	78	68	58	48	39	30	21	13	5		
65	95	90	85	80	70	61	52	44	35	27	20	12		
70	95	90	86	81	72	64	55	48	40	33	25	19	3	
75	96	91	86	82	74	66	58	51	44	37	30	24	9	
80	96	91	87	83	75	68	61	54	47	41	35	29	15	3
85	96	92	88	84	76	70	63	56	50	44	38	32	20	8
90	96	92	89	85	78	71	65	58	52	47	41	36	24	13
95	96	93	89	86	79	72	66	60	54	49	44	38	27	17
100	96	93	89	86	80	73	68	62	56	51	46	41	30	21
105	97	93	90	87	81	74	69	63	58	53	48	43	33	23
110	97	93	90	87	81	75	70	65	60	55	50	46	36	26

APPENDIX VI

The Beaufort Scale for Estimating Wind Speed

Beaufort number	Wind	Wind speed (km/hr)	Noticeable effect of wind speed
0	Calm	1	Smoke rises vertically.
1	Light air	1—6	Wind direction shown by smoke drift but not by wind vanes
2	Slight breeze	7—12	Wind felt on face; leaves rustle; wind vanes moved by wind
3	Gentle breeze	13—18	Leaves and twigs in constant motion; wind extends light-flag.
4	Moderate breeze	19—26	Raises dust and loose paper; small branches are moved.
5	Fresh breeze	27—35	Small trees in leaf begin to sway.
6	Strong breeze	36—44	Large branches in motion; whistling in telegraph wires; umbrellas used with difficulty.
7	Moderate gale	45—55	Whole trees in motion, inconvenience felt when walking against wind.
8	Fresh gale	56—66	Twigs break off; progress generally impeded.
9	Strong gale	67—77	Slight structural damage occurs; chimney tops and hanging signs blown away.
10	Whole gale	78—90	Trees uprooted; considerable structural damage.
11	Storm	91—104	Very rarely experienced; accompanied by wide-spread damage.
12	Hurricane	above 104	Very violent and destructive.

GLOSSARY

Anemometer : An instrument meant for measuring wind speed. It comprises a system of cups and a speed indicator.

Aneroid Barometer : A portable instrument commonly used for measuring atmospheric pressure It consists of a partially vacuumed metallic box, a flexible lid and a needle working on a lever. A change in atmospheric pressure is indicated by the motion of the elastic and sensitive top of the box.

Atlas : A collection of maps bound into a volume Generally, these maps are drawn on small scales. The term atlas first appeared on the title page of the collection of Mercator's charts in A D 1595. The origin of the word, however, goes back further into the past, as it relates to 'Atlas' supporting the heavens according to mythological beliefs.

Azimuthal Projections : A type of map projections in which a portion of the globe is projected upon a plane tangent to the globe at some specific point, e.g., the north or the south pole. These projections are also known as True Bearing Projections, because all points have their true compass direction from the centre of the map drawn on these projections The word azimuth means bearing or direction.

Bar Graph : A series of columns or bars drawn proportional in length to the quantities they represent. They are drawn on a selected scale. They may be drawn either horizontally or vertically.

Barometer : An instrument for measuring atmospheric pressure which is the weight of the air column at a given place and time. Fortin's and aneroid barometers are examples of such an instrument.

Bench Mark : Exact height of specific points on prominent and durable material objects like rocks or buildings in the field, recorded for the sake of permanent'reference. On a map, a bench mark is indicated by B M., followed by the number giving the actual height of the mark above mean sea level .

Cadastral Maps : Maps drawn on a fairly large scale to show accurately the extent and measurement of every field and plot of land. The word *cadastre* meads "a public register of the lands of a country for defining property and levying taxes".

Cartogram : The representation of statistical data on a map in a diagrammatic way by purposefully distorting the original shape, etc., of the area concerned. Usually, it is a highly abstracted and simplified map highlighting a single idea in a diagrammatic way. It is one of the important and popular tools of modern geography.

Cartography : The science of preparing all types of maps and charts and includes every operation from original surveys to the final printing of maps.

Central Meridian : When a meridian, whatever its value, stands at the centre of the projection, it is called the central meridian and has nothing to do with the prime meridian.

Central Tendency : The tendency of quantitative data to cluster around some value.

Chain : A length-measuring device used for the purpose of obtaining horizontal distances between two points. Chains are of various lengths, e.g., metric chains of 20 and 30 metres, Engineer's chain of 100 feet, and Gunter's chain of 66 feet.

Chain Survey : Measuring of horizontal distances by the chain and the tape. This relatively simple method is used for surveying small areas along with their details with reasonable accuracy.

Choropleth Maps : Maps drawn on a quantitative areal basis, calculated as average values per unit of area within specific administrative units, e.g., density of population and percentage of urban to total population

Class Interval : The difference between the lower and upper limits of any class of a frequency distribution is known as its class interval.

Climatic Map : A map of the world or a part of it, showing average conditions of temperature, pressure, wind, precipitation, and sky conditions over a period of time.

Composite Measurement : A measurement of the overall effect of several correlated variables.

Conical Projections : A type of map projections in which a map is projected on a paper cone imagined to be either resting on the globe or intersecting it in a particular manner. A conical projection may be with one standard parallel or with two standard parallels.

Contours : Imaginary lines joining all the points of equal elevation or altitude above mean sea level. They are also called "level lines"

Contour Interval : Interval between two successive contours. It is also known as vertical interval, usually written as V.I. Generally, it is constant for a given map.

Correlation Co-efficient : A measure of the degree and direction of relationships between two variables.

Cross-section : A side view of the ground cut vertically along a straight line. It is also known as a section or a profile.

Cumulative Frequency : The measurement of distribution of values in the different class intervals expressed as a percentage of the total frequencies either above or below specified value

Cylindrical Equal-area Projection : A kind of cylindrical projection in which the area between two parallels is made equal to the corresponding surface on the globe by decreasing the distance between the parallels progressively towards the poles

Cylindrical Projections : A group of projections in which a cylinder is presumed to have enveloped or cut the globe in a particular manner. All cylindrical projections form rectangles.

Diagonal Scale : An elaboration of the graphic scale by which one can measure up to a minute part of a centimetre or an inch. It gives divisions much smaller than the secondary divisions of a graphic scale.

Dispersion or Spread : The degree of internal variations in the different values of a variable.

Distribution Maps : Maps, which with the aid of certain symbols like dots and shading schemes, depict location of various geographic elements and their frequency or intensity or density as the case may be. For example, they may show distribution of crops, livestock, population, industrial output, etc., in a given area

Drainage : A system of rivers or streams which drain all the rain water that falls in a region.

Flow Maps : Maps in which the "flow" or movement of people or commodities is represented by ribands whose thickness is proportional to the quantity of goods or the number of people moving along different routes.

Frequency Distribution Table : The arrangement of the number of values of a variable falling in different ranges. These ranges of the values of the variable are known as classes and the number of values falling in each class is known as frequency.

Great Circle : A circle on the earth's surface whose plane passes through the centre of the earth bisecting it into halves. The shortest distance between any two points on the earth's surface is along the arc of a great circle.

Hachures : Small straight lines drawn on a map along the direction of maximum slope, running across the contours. They give an idea about the differences in the slope of the ground.

Hill-shading : A method of showing relief on a map by shading only those slopes that face south and east, presuming that the source of illumination is in the north-west.

Histogram : A graphical representation of a frequency distribution, such as seasonal frequencies of rainfall.

Homolographic Projection : A projection in which the network of latitudes and longitudes is developed in such a way that every graticule on the map is equal in area to the corresponding graticule on the globe. It is, therefore, also known as equal-area projection.

Index Number : A measure which serves to depict the proportional changes of a characteristic independent of initial magnitude of the data and of the unit in which they are measured

Interpolation of Contours : Drawing contours with the help of spot heights given on the map

Isobars : Imaginary lines drawn on a map joining places with equal barometric pressure, reduced to sea level, in order to eliminate differences due to varying altitudes.

Isohyets : Imaginary lines drawn on a map joining places with equal amount of rainfall over a given period of time

Isopleth Maps : Maps drawn by linking points with similar values or similar quantities, e.g., isotherms.

Isotherms : Imaginary lines drawn on a map joining places with equal temperature, reduced to sea level.

Land Use : The use which is made by man of the surface of the land. In sparsely populated areas, it includes occupation of land by natural and semi-natural vegetation.

Layer Colouring : A method of showing relief with the help of contours, especially in atlas and wall maps. The contour scheme is followed universally, e.g., shades of blue for sea, green for low-lying areas, brown for higher and pink for still higher lands.

Linear Scale : A method of expressing scale with the help of a line conveniently divided and subdivided, so that distances on the map can be directly measured and read off from a map.

Line Graph : A smooth line drawn through a series of points, which are determined by means of two co-ordinates along the X-axis and the Y-axis. Change in one variable is shown with reference to another. Usually, it is used for presenting data regarding rainfall, temperature, growth of population, production, etc.

Location Quotient : The ratio of the percentage of some characteristic of an area to the same percentage in the region.

Lorenz Curve : A graphical method of showing the concentration of some characteristics.

Macro, Meso, Micro : Terms often used in regional geography to differentiate regions according to their size and level in an interdependent system of regions. *Macro* refers to large size, *micro* to the smallest, and *meso* to an intermediate level.

Magnetic North : The direction pointed to by the needle of the magnetic compass. It is determined with reference to the magnetic north pole, which is different from the geographic north pole and also moves slowly from time to time.

Map : A conventional representation of any area of the earth's surface, small or large, drawn to scale on a flat surface.

Map Projection : A method of transferring the network of parallels and meridians, i.e., earth's grid, from the spherical surface of the earth to a plane surface.

Mean Deviation : A measure of dispersion derived from the average of deviations from some central value. Such deviations are taken absolutely i e their signs are ignored. The central value is generally mean or median.

Median : It is the value which divides the number of observations in such a way that half the values are less than this and half of them are more. If the values of a variable are arranged in either ascending or descending order, the median is the middle value.

Mode : The mode is that value of a variable which occurs maximum number of times.

Meridian Scale : The distance along a meridian of longitude which is measured between two parallels of latitude.

Optical Square : An instrument used in chain survey for setting out right angles for measuring short distances from the chain to the objects nearby.

Orthomorphic Projection : A type of projection in which every care is taken to preserve the correct shape of a given area of the earth's surface. It is, therefore, also known as a correct shape projection.

Pantograph : An instrument used for enlargement and reduction of maps with accuracy.

Parallel Scale : The distance along a parallel of latitude which is measured between two meridians. The parallel scale is always correct along the standard parallel.

Plane Table : A surveying instrument by means of which a map of a small area may be drawn and completed in the field with a fair amount of accuracy. It is also useful for filling the details into a network of triangles.

Quartile : Quartiles are the values of the variable which divide the number of observations in four equal parts.

Rain Gauge : An instrument for measuring accurately the amount of rainfall at a given place over a fixed duration, say, 24 hours.

Ranging Rod : A wooden straight rod, coloured red and white, with a metal shod at one end to fix it securely in ground. Ranging rods are used in chain survey, plane tabling and other methods of surveying

Relative Dispersion : The ratio of the measure of dispersion of a frequency distribution to its measure of central tendency.

Relief : A collective name given to surface features of the earth such as mountains, plateaus, plains, valleys and water bodies The elevations and depressions of land surface such as mountains, plains and valleys are called relief features

Relief Map : A map showing relief of an area on a flat surface by means of any of the methods such as contours, form-lines, layer colouring, hachures, hill-shading or a combination of these.

Rhumb Line : A straight line of constant bearing intersecting all intermediate meridians at the same angle in a given projection.

Scale : The ratio which a distance between any two points on a map bears to the actual distance between the corresponding points on the ground.

Scatter Diagram : A diagram showing the joint variations of two characteristics on a graph paper.

Spot Height : The exact height of a given spot found out with the help of surveying instruments. It is shown on a map by a dot followed by a number expressing the height in metres or feet.

Standard Deviation : The most commonly used measure of dispersion. The standard deviation is the positive square root of the mean of the squares of deviations from the mean

Standard Parallel : The parallel of latitude of any projection along which the scale is true.

Surveying : An art of making observations and measurements, both linear and angular, in order to determine the relative position of points on the earth's surface. It helps to determine the boundaries, extent, position and relief of any part of the earth's surface.

Tabulation : The process of putting raw data into a systematically arranged tabular form.

Topographic Map : A map of a small area drawn on a large scale depicting detailed surface features both natural and man-made. Relief in this map is shown by contours.

True North : The direction towards which the north pole of the earth points. It is also known as geographic north.

Variable : Any characteristic which varies. A quantitative variable is a characteristic which has different values the differences of which are quantitatively measurable Rainfall, for example, is a quantitative variable, because the differences in its different values at different places or at different times are quantitatively measurable. A qualitative variable on the other hand, is the characteristic the different values of which cannot be measured quantitatively. Sex, for example, is a qualitative variable, It can be either male or female. A qualitative variable is also known as an *attribute*.

Watershed : A narrow elevated tract of ground separating water flowing in opposite directions.

Weather : The condition of the atmosphere at a given place and time with respect to atmospheric pressure, temperature, humidity, precipitation, cloudiness and wind. These factors are known as weather elements.

Weather Forecast : Prediction with a reasonable amount of certainty the conditions of weather that would prevail in the coming 12 to 48 hours in a certain area.

Wheel Diagram : A circular diagram in which a circle is divided into sectors for presenting data in percentage

Wind Rose : A diagram showing the frequency and direction of wind blowing from each of the eight directions at a given place over a period of time.

Wind Vane : An instrument used for determining wind direction.